SCIENCE TEACHER'S WORLD

Teacher's edition of Science World • May 19, 1959

Teaching science out of doors

■ Many years ago it was the writer's privilege to take a summer course at Cornell University, a course called "Teaching Nature Study Out of Doors." Actually, it was a series of weekend, overnight excursions, each led by an eminent specialist, to places of special interest. One excursion was led by the venerable limnologist, the late Professor James Needham. I well recall a Friday night when we were all gathered about a campfire after a very satisfying cook-out supper. The fire had died down to a few blue flames hovering over glowing embers. Dr. Needham reached into his back pocket, took out some folded paper, and spoke:

"By the way," he said, "just before I left home this afternoon, I spied this manuscript of mine on the desk. I thought it might be of some interest to you, so I brought it along."

He slowly unfolded the pages and, by the light of a flashlight, began to read. His manuscript was entitled "The Common Ground of Poet and Naturalist." The burden of his thesis was this: The poet responds to nature emotionally; the naturalist (scientist), intellectually. Yet many a poet shows keen powers of observation, and many a naturalist is deeply moved emotionally by what he observes. This thesis was supported by quotation after quotation from the writings of poets and naturalists.

Science teaching out of doors should provide for the learner a delicate balance between intellectual and emotional experience. The emotional component often stems from the teacher's own genuine enthusiasm. The intellectual component is provided by skill in teaching. What are some elements of good science teaching out of doors?

1. *Calling to attention.* So many things that can initiate learning are sometimes overlooked: a piece of string in a bird's beak, the way a dragonfly dips the tip of its abdomen repeatedly into the surface of a pond, a field of spider webs bejeweled by morning dew, a wasp dragging a grasshopper along the ground, the "trail" of wind on the surface of a lake, the direction of floating clouds, the position and phase of the daytime moon, the dissolution of the morning mist, tunnels under the leaf-laden forest floor, the position on the horizon of the setting sun, holes in the sand in the wake of a receding ocean wave, the gyrations of a hawk, the pothole in a rock under the falling water of a stream.

Each of these can be the beginning of an adventure into the unknown, of an exciting exploration, and of the joy of further discovery. If you want to do an effective job of teaching science outdoors, you must become the eyes and ears of your charges. Soon you will experience a kind of feedback: your students will themselves become sensitive and alert to what goes on about them. When you go out into the field with ten such sensitized young people, you will have an additional twenty eyes and twenty ears. *They* will call to *your* attention things you would ordinarily overlook. At this point, you have an additional task as a teacher; you must arouse curiosity.

2. *Arousing curiosity.* You arouse curiosity when you are yourself curious about something that has

Last issue of Science World for this semester

This is the final issue of the 1959 spring semester. We hope that you have found **Science World** both helpful and stimulating in the classroom and that you and your classes will re-subscribe for the 1959-60 school year.

If so, may we suggest that you take advantage of the tentative order card bound into this issue? Simply fill out the card, estimating the number of students you expect to have next fall, and drop it in the nearest mailbox. This card places you under no obligation, but it will ease the fall rush for you and for us.

Memo from IBM®

Twenty-two hundred years ago, from the Hindu Kush to the River Ganges, mighty King Asoka posted his edicts on pillars across India. These edicts contained the earliest known ancestors of the numerals we use today.

During the early centuries, King Asoka's crude symbols changed to shapes more familiar to us. More important, at some point in early Hindu history, numerals were arranged in a *place system*—and given characteristics that have won them world-wide acceptance.

For it is the place system that makes the Hindu number scheme so compact, so easily learned, and above all . . . so simple to use. The system was built around the base ten. (The base could have been any number: the Hindus probably chose ten because they counted on their fingers.) Individual symbols are needed only for 0 to 9.

In contrast, the Greeks, without a place system, had to memorize 27 different symbols just for the numbers 1 to 999. Thus, each 8 in 888 was different: Omega (800) Pi (80) Eta (8), and many number relationships were obscured. While the Romans used few symbols, they had to keep repeating them: 888 was DCCCLXXXVIII—twelve symbols. In both these ancient systems, multiplication and division were so difficult that they were done on the abacus.

The Hindu numerals with their place system were carried westward to Bagdad by merchants and scholars. There their virtues were expounded in 825 A.D. by a learned Arab, al-Khowarizmi. Trade and war alike brought the Arabs in close contact with the western world. By the 10th century the new numerals had reached Spain and eventually, al-Khowarizmi's book was translated into Latin.

Yet with all their advantages, the new numerals took centuries to win Europe. They were scorned as pagan, sometimes banned as too easily forged—one stroke could turn 0 into 6 or 9. Scarcity of writing materials kept the abacus in use. It was not until the late 15th century that the Hindu-Arabic numerals prevailed and were carried everywhere in inexpensive printed books. At last anyone could learn to use numbers—and the door was open to modern mathematics.

been discovered. Where is the bird with the string in its beak going? Where is the wasp dragging the grasshopper? Why are the tunnels under the forest floor most common near the bases of trees? Why are the clouds over the lake floating in a direction opposite to that of the wind near the surface of the lake? Why is the morning after a clear night colder than the morning after a cloudy night? Questions such as these are invitations to exploration and learning.

3. *Encourage and guide active exploration.* "The dragonfly is laying its eggs in the water," you explain. "Let us find its young." This calls for an expedition. Pond water is examined. Mud is scooped up from the bottom and explored. When the young are found, they are seen not to resemble dragonflies at all. They have no wings. Their "mouths" unfold into a formidable "steam shovel." How do these crawlers change into dragonflies? How do they get out of the water? This may call for some reading, which, in turn, will call for being on the lookout for molts on stems or rocks protruding from the water.

Do the winds "observed" near the surface of a lake and winds high over the lake *always* blow in opposite directions? Do clouds floating in one direction differ in form from clouds floating in another direction? Suggest that the students keep a record to find out. Suggest that they see what some books on weather say about moving air.

A group stands watching Jim, as he holds a salamander by its tail. The tail breaks off and is left wiggling in Jim's fingers. In the meantime, another boy in the group catches the salamander before it escapes. How long will the tail continue to wiggle? How long will the salamander live without its tail? Suggest that a record be kept to find out.

At breakfast time, the moon is over a certain building. Will it be in the same position at breakfast time tomorrow? The students can observe its position at the same time on each of several days to find out. When these observations are made and recorded, they will call for an interpretation. Even if a student has just completed a "unit" on astronomy in school, this experience in the field may well be his first real insight into an astronomical phenomenon.

One night a student stands alone, watching the queen of the night play hide-and-go-seek through the openings in clouds of drifting silver. He experiences a feeling of beauty and awe that could not be evoked by the most skillfully contrived "visual aid." If, at the same time, the young person is aware of the air mass in which the clouds are suspended, of the sun whose light is being mirrored by the moon, and of the majesty with which the moon is orbiting the earth, what science teacher would not consider himself well rewarded?

— Zachariah Subarsky

Gold key requests

If you are planning to award our gold-filled key to one of your students, now is the time to let us know. Keys will be given to teachers who have ordered ten or more classroom subscriptions to Science World. Please note that the keys and their accompanying certificates are available ON REQUEST only. They should be requested according to this scale:

Student orders	Keys
10-100	1
101-200	2
201-300	3

and so on for as many student copies as you have ordered.

The keys may be awarded at your discretion to whichever student you wish to encourage with special recognition.

Address requests to: Teacher-Service Department, Science World, 575 Madison Avenue, New York 22, N.Y.

MEMO

To: Science teachers

Subject: Ways to use this issue of SCIENCE WORLD in the classroom

The world's biggest ice cube

PHYSICS TOPICS: buoyancy, strength of materials
GENERAL SCIENCE TOPICS: forms of water, freezing

This article is described as stranger than fiction, and the description is indeed appropriate. The article brings to light large-scale experiments carried on during World War II in making ships with hulls of reinforced ice. The reinforced ice was 10 per cent wood pulp. Since ice itself weighs less than the same volume of water and since the hull was hollow, such a vessel is extremely buoyant. What's more, any holes made in the hull by an enemy action could be patched by refreezing. Students might make such a boat in a home freezer, using a large waxed-paper mold to form the hull.

Class discussion

1. Why was it necessary to reinforce the ice?
2. How were holes mended?
3. How did the ice ship stand up in warm water?
4. What was the purpose of the ice-hulled aircraft carrier?

Class projects and experiments

1. Make a mold for a boat hull from waxed cardboard, sealing the mold's seams with molten candle paraffin. Fill the mold with water, and place it in a home freezer. Make a second ice-boat hull in the mold; this time 10 per cent of the ice should consist of shredded paper toweling (which is wood pulp). Test both hulls in a large sink or tub of water. Which lasts longer? Next, drop heavy metal balls on the ice hulls to compare their strength. Why does the plain ice hull shatter more easily than the other hull?

The subtle storm

PHYSICS TOPICS: magnetic field, induced currents, radio transmission, auroras
GENERAL SCIENCE TOPICS: communication, magnetism

This is the conclusion of an extraordinary three-part story on magnetic storms. In the conclusion, the following spectaculars are described: the giant aurora borealis that was seen as far south as Mexico; magnetic effects on transoceanic cables, whose induced voltages reached thousands of volts; the curtailment of usual radio transmission, which left thousands of aircraft over the seas without radio communication. In this last part of the article students will learn something about the scientific measurements made during magnetic storms and the part this activity played in the IGY program. This is another article that enriches the courses in physics and general science by carrying students beyond the confines of the textbook and the classroom.

Class discussion

1. What was the extent of the aurora during the great storm?
2. How does high voltage come to flow in cables during magnetic storms?
3. Why do magnetic storms affect radio communication?
4. How are aircraft affected by magnetic storms?
5. What kind of radio communication continues unabated during a magnetic storm?
6. How much do we know about the nature of magnetic storms?

Class project

Inside a cardboard or plastic geography globe, mount a strong bar magnet so that its south pole is located at the approximate position of the north magnetic pole. On the surface of the globe, around the Arctic Circle, cement tiny magnetic compasses. Note the orientation of the needles. Above the north magnetic pole place a coil, consisting of fifty turns of No. 18 bell wire, so that the plane of the coil is parallel to the equator. Simulate a magnetic storm by sending current intermittently through the coil by means of dry cells. Have students watch what happens to the compass needles.

New weapon against polio

BIOLOGY TOPICS: immunity, viruses
GENERAL SCIENCE TOPIC: polio prevention

This article describes a new technique for producing immunity against polio, using weakened live viruses rather than killed-virus vaccine of the Salk type. The article

explains the advantages that will accrue to mankind if the live-virus vaccine, which is taken by mouth, continues to prove satisfactory in experiments. Students who read the article will get an insight into the nature of a virus and the way it enters and grows inside a body cell. The nature of polio is explained carefully to show why this new type of immunization may prove to be superior to the Salk vaccine in preventing the spread of the disease. This is a superb article for introducing or closing the topic of immunity.

Class discussion

1. How does the Salk vaccine differ from the live-virus vaccine described in the article?
2. How was the virus weakened?
3. How can a person who is immunized against polio by Salk vaccine still cause the disease to spread?
4. How does the live-virus vaccine work?
5. What is a virus?
6. How do viruses grow and multiply?

Sea water: fuel for the future?

CHEMISTRY TOPIC: hydrogen isotopes
PHYSICS TOPIC: fusion
GENERAL SCIENCE TOPIC: atomic energy

The fusion of hydrogen from sea water is a subject that keeps popping up in the news. In this article students will find a wealth of basic ideas underlying the possible future use of controlled hydrogen fusion for energy. The many unsolved problems are clearly defined. In addition, students get an introduction to the isotopes of hydrogen and learn where fusion research is going on in this and other countries. The questions and answers, following the introduction, highlight the problems and possible techniques of fusion.

Class discussion

1. When will atomic power become economically necessary in this country? Why?
2. What are fossil fuels?
3. Why is the ocean considered to be an almost endless source of energy?
4. How is fusion to be carried out?
5. Why is the container problem one of the most serious problems in developing fusion?

Class demonstration

Use magnets to cause the beam in a Crookes tube to move. Point out that the beam is made up of ions and that the experiment illustrates the effect of a magnetic field on a plasma.

Suddenly it's 1960

TOPIC: science fair projects

If your students are looking for ideas for science fairs, this article fills the bill. Enough information is given in each project area to give a student a start. In addition, the back issues of SCIENCE WORLD and SCIENCE TEACHER'S WORLD provide other ideas for projects. These can be called to the attention of students. You may want to prepare an index of these sources. A committee of students under your supervision could do the actual compiling of the index.

Life-scale models: museum caliber

BIOLOGY TOPIC: forms of life
GENERAL SCIENCE TOPIC: animal models

This is a how-to-do-it article that can provide classroom teaching material and models for a science fair display. After a bit of practice, many students can become skillful at casting models, while others may be more gifted as painters of the models. Co-operation with the school's art department may be very helpful for the science teacher who is not confident in his or his students' artistic ability. The article might well serve to correlate science and art work, and the model-making might be done in the art room or studio.

Problems

1. How are the molds made?
2. Why is greasing of the original animal form necessary?

Insect songsters

PHYSICS TOPIC: music
BIOLOGY TOPIC: insects
GENERAL SCIENCE TOPIC: sound

Students will find this one of the most fascinating insect articles that has been written. It provides them with interesting and accurate information concerning sounds produced by insects. The relationship of the number of chirps per minute to the air temperature can lead to interesting experiments at home or in school. The article is excellent for motivating the study of sound or insects. In biology classes students can carry on experiments with insects in cages.

Class discussion

1. How do crickets and katydids produce sound?
2. Why has an insect no true voice?
3. How does temperature affect the sounds produced by crickets and katydids?
4. How might you keep crickets in captivity?

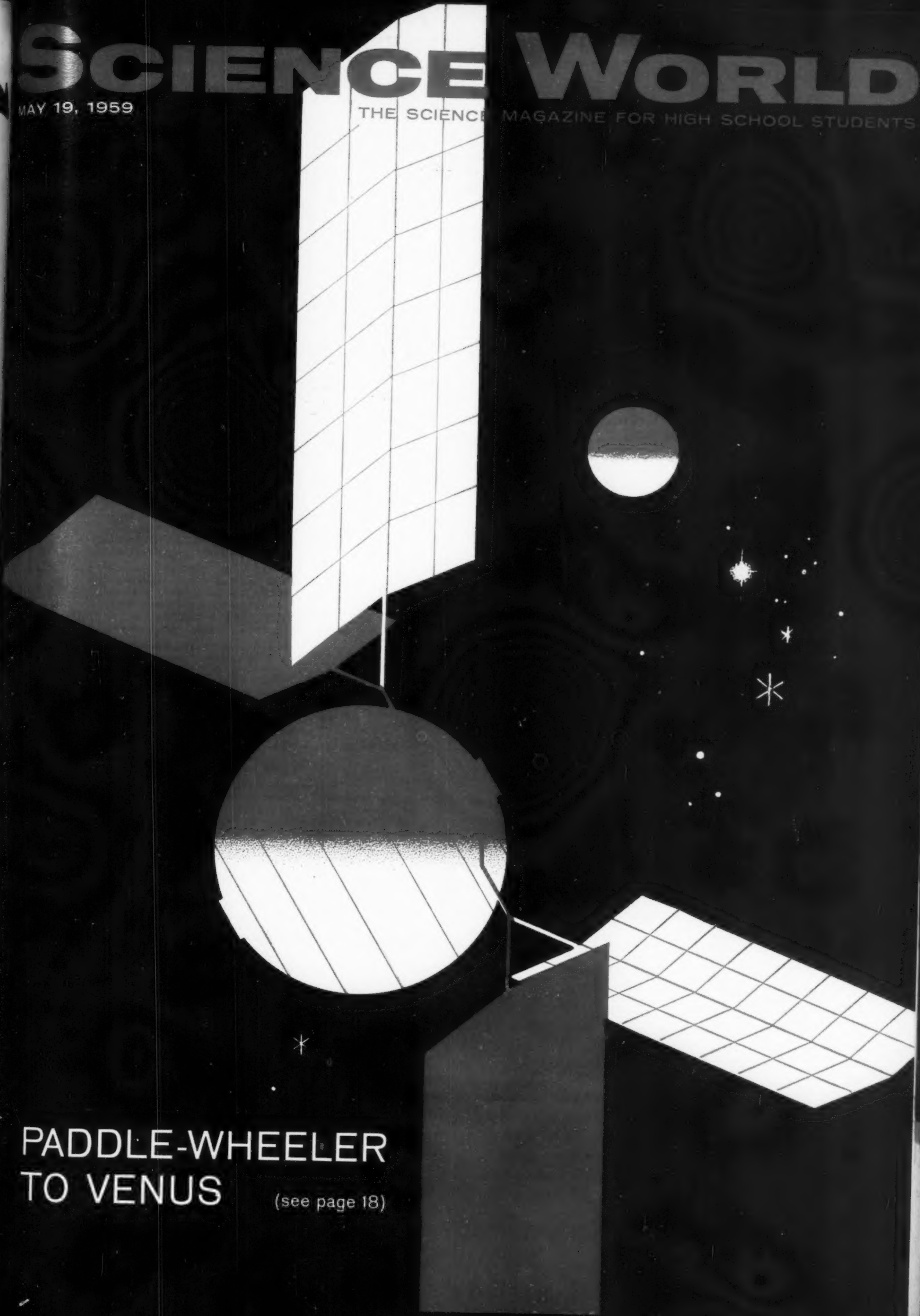
Class projects and experiments

1. Measure temperature by means of insect chirps.
2. Keep insect songsters in small window-screen cages in the classroom. Feed them the diet described.
3. Set up a science fair exhibit of chirping insects. Make models of the sound-producing parts.

SCIENCE WORLD

MAY 19, 1959

THE SCIENCE MAGAZINE FOR HIGH SCHOOL STUDENTS



PADDLE-WHEELER TO VENUS

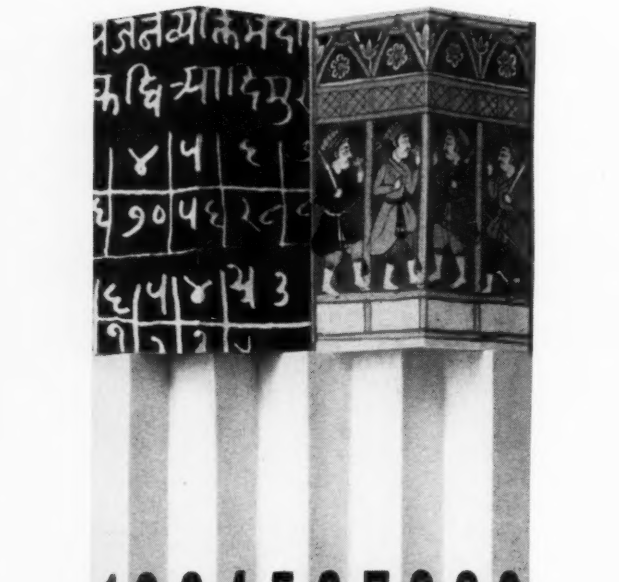
(see page 18)

MATHEMATICS SERVING MAN

TEN GIFTS FROM ANCIENT INDIA:

Hindu scholars of nearly two thousand years ago gave us ten servants we all use: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. With only these 10 symbols and the place system that came with them, we can express any number, no matter how large, how small.

Arabian mathematicians learned these numbers from Indian sages, and brought them to Europe in the tenth century. As Western merchants and scholars found how much easier it was to multiply 217 by 29 than CCXVII by XXIX*, the old Roman numerals were abandoned.



However, the shape of the new numerals, hand-copied repeatedly by Medieval scribes, varied widely until the coming of the printing press in the fifteenth century. Then inexpensive printed books made the mathematical classics as well as the new commercial arithmetics available throughouf the length and breadth of Europe—and fixed the numerals in type styles still used today. Simple enough for a grocery bill, so adaptable they can describe the basic laws of the universe, these ancient numerals are woven into the fabric of our lives. **IBM**®

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*MMMMMMCCXCIII or 6,293

SCIENCE WORLD is published biweekly during the school year, September through May inclusive (8 issues per semester, 16 issues per school year), except during school holidays and at mid-term by Street & Smith Publications, Inc., 575 Madison Avenue, New York 22, N.Y. Second-class postage paid at New York, N.Y., and at additional mailing offices. © 1959 by Street & Smith Publications, Inc., in the United States. Subscriptions, U.S., $1.00 per semester (8 issues); two-semester subscription (16 issues), $1.50; single copy, 15¢. Back copies, 25¢. Canadian subscription rates are the same as United States; additional postage for countries in Pan American Union: one semester, $1.00, two semesters, $2.00; cost of additional postage for other foreign countries: one semester, $1.50, two semesters, $3.00. Address all subscription mail to Science World, 304 East 45 Street, New York 17, N.Y. Send notice of undelivered copies on form 3579 to: Science World, McCall Street, Dayton 1, Ohio.
Printed in U.S.A. 24

SCIENCE WORLD
THE SCIENCE MAGAZINE FOR HIGH SCHOOL STUDENTS

Contents • May 19, 1959 • Vol. 5 • No. 8

Features

Stranger Than Fiction

Departments

Cover by John Ballantine

This is last spring issue of SW

With this issue we wind up the spring semester of SCIENCE WORLD. There will be no publication during June, July, and August. Our next issue will be published in September.

If your subscription is part of a classroom group, now is the time to renew. Ask your teacher to enter a tentative order (which can be revised in the fall). There's no need to pay now for a tentative order. Our bill will not be sent out until next fall.

SW interview

Sea water: fuel for the future?

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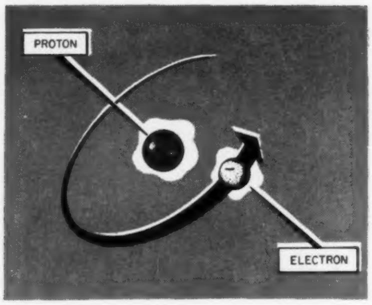

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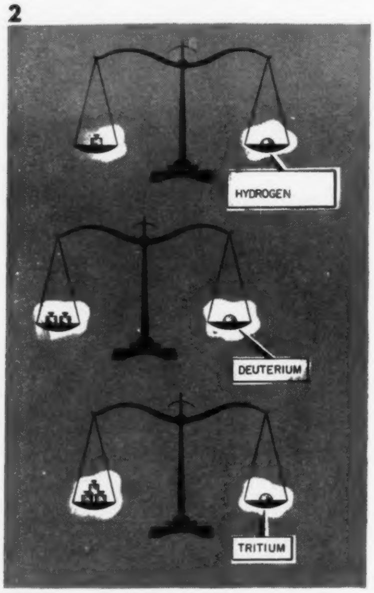

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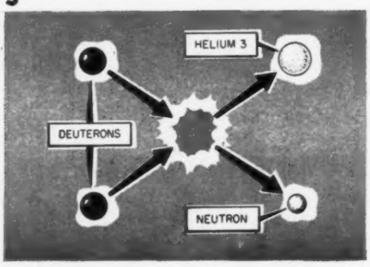

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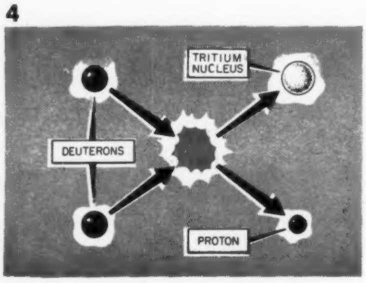


ORDINARY HYDROGEN ATOM (1) consists of one electron revolving around nucleus of one proton. Nucleus of deuterium atom has extra neutron and twice the mass of ordinary hydrogen nucleus (2). Tritium nucleus has three times the mass. Energy is released when two deuterium nuclei fuse and emit a neutron (3) or a proton (4).

■ Someday man will use fuel obtained from water. The fuel will be hydrogen, and it could provide the world with unlimited amounts of power. For two-thirds of the atoms that make up water are hydrogen atoms.

Hydrogen atoms can be separated from the oxygen atoms in water and burned by ordinary combustion, in the same way that gasoline is burned as fuel. But this kind of burning yields only ordinary amounts of heat energy.

Another kind of hydrogen "burning" is of far greater interest to the scientist. This is fusion, the process that goes on in the fiery furnace of the sun. The thermonuclear energy released by fusion is millions of times greater than that released by ordinary burning.

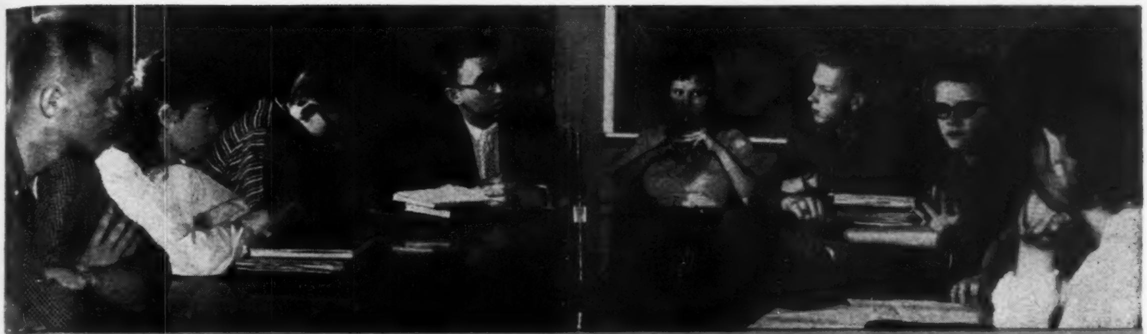
Thermonuclear energy is released when the nuclei of atoms in the lightest elements are made to combine with each other (fuse) at very high temperatures.

Hydrogen, one of the most plentiful elements on the earth, is the lightest atom. It has at its nucleus only a single proton (positively charged) around which an electron (negatively charged) revolves. Not every hydrogen atom is this simple, however: about one in every 6,000 hydrogen nuclei contains a neutron (uncharged) as well as a proton; it is therefore twice as heavy as an ordinary hydrogen nucleus. This heavy atom differs only in mass from the ordinary hydrogen atom; chemically, they are the same. Heavy hydrogen is called *deuterium.* (It is possible to prepare water in which the hydrogen atoms are the deuterium isotope. This is known as heavy water — D_2O instead of H_2O.)

There is an ever rarer isotope of hydrogen that is three times heavier than ordinary hydrogen — tritium. Deuterium and tritium are the principal fuels that scientists hope to burn in a thermonuclear reactor.

The actual energy release comes from nuclear processes associated with the fusion of two of these heavier isotopes. For example, two deuterium nuclei may collide and fuse into a single "excited" nucleus, which then emits either a proton or a neutron. The final products of the reaction weigh slightly less than the initial nuclei that fused. The weight lost appears as thermonuclear energy: mass is converted into energy. Another energy source is the collision and fusion of a deuterium nucleus with a tritium nucleus.

— Drawings and photograph courtesy Union Carbide Corp.



Oak Ridge High School science students interview Dr. Robert A. Charpie, Assistant Director of Oak Ridge National Laboratory. The students: Stan Anderson, Anita de Laguna, Eleanor Groeniger, George Holt, Patsy Jackson, Barbara Mann, Currie Nunnery, Frank Pollard, David Ravage, and Stephen Thornton. The subject:

Controlled thermonuclear fusion

If man can learn to control fusion, he will be able to produce all the energy he needs for millions of years to come. How close are we to that goal? Recently, a group of science students at Oak Ridge High School in the "Atom City" of Oak Ridge, Tennessee, interviewed Dr. Robert A. Charpie, Assistant Director of Oak Ridge National Laboratory, on the subject of thermonuclear research. Dr. Charpie was co-ordinator of the United States Fusion Research Exhibit at last year's International "Atoms-for-Peace Conference" in Geneva. Here is a transcript of some of the questions and answers at that interview:

Q. How important a part will fusion play in the future of America?

A. That's hard to say, because we aren't sure that fusion will ever be a successful form of harnessing energy. However, let me go at your question this way:

The basic commodity in which America deals is energy. I suppose it's fair to say that our economy is at a high level today because in the nineteenth century we developed a successful economic system that capitalized effectively on the availability of large blocks of cheap energy. Now, the fuel from which we make energy in this country is running out very quickly. So it is necessary, assuming that the type of society we have today exists for a long time, that we obtain a source of energy which is essentially endless. Coal, oil, gas — the fossil fuels — take millions of years to make, and we're running through them very rapidly. The only sources of energy that appear now to be inexhaustible are the sun and the ocean.

Fusion attempts to "burn" the water of the ocean as fuel. Conceivably, if we're successful in establishing controlled fusion, we would then be in a position to continue rather indefinitely our present form of society. Whether or not we'll be successful, I don't know, but you can see that the problem will remain important for many, many years to come. Even if it takes several hundred years to solve the problem of fusion, we must be perfectly willing to work on it.

You understand, of course, that we have not yet established that controlled fusion is possible experimentally in the laboratory. The only power-producing fusion reactions we can really observe are in stars.

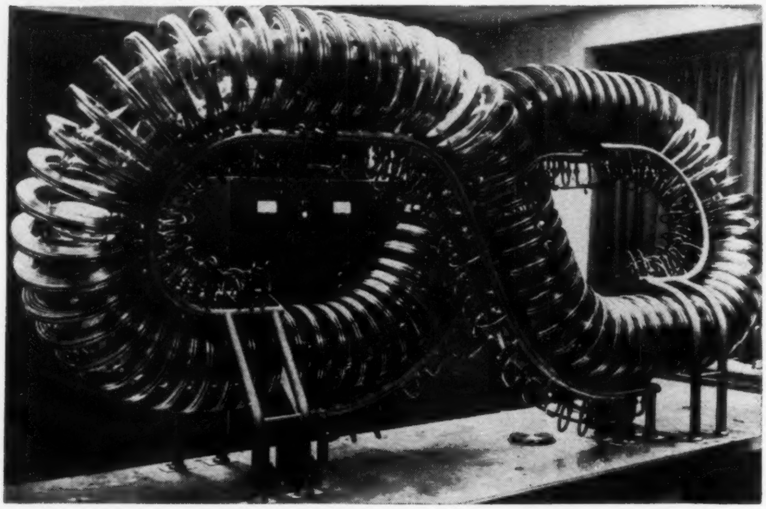
Q. Where is the major work being done to learn how to harness this tremendous energy?

A. Work is being done on fusion all over the world today. In the United States the principal effort is centered at four sites, all of which are operated for the United States Atomic Energy Commission: Los Alamos Scientific Laboratory outside the city of Santa Fe (N.M.); the University of California Lawrence Laboratory at Berkeley and Livermore; Princeton, so-called Project Matterhorn; and here at Oak Ridge National Laboratory, which is operated by Union Carbide Corporation. Outside the United States every major country is involved in large experimental programs on fusion.

Q. You said that fusion reactions have only been observed in stars. I'd always understood that we *had* been able to produce fusion experimentally. But since this isn't so, what have we achieved?

A. We can produce individual fusion reactions — a deuterium atom strikes a deuterium atom and a fusion reaction takes place; such a reaction would go on in a controlled fusion device. But in order to have a real honest-to-goodness fusion power producer, you must have a continuing reaction. That is, you must have a collection of hot ions and electrons (these are

— Photograph courtesy A.E.C.



DEMONSTRATION MODEL of experimental U.S. fusion apparatus. Its principle is this: ionized deuterium gas, so hot it could turn all solids to vapors, is held in figure-eight tube by strong magnetic field produced by electric current in coils.

in random motion with respect to each other) heated to such temperatures that they strike each other and react. This is different from taking a single atom, accelerating it, impinging it on a single target atom, and observing the reaction.

The ions in a star are confined by gravitational forces to the interior of the star, so that an energetic ion wanders around, bouncing off other ions, until once in a while it makes a chance collision that produces a reaction. There's no way in which the ion can avoid eventually producing a reaction. Now, in the laboratory, if you take a beam of very energetic particles, bounce them on a target, and observe reactions, perhaps only one out of a million particles will produce a reaction. What happens is that most of the particles strike the target and simply give up their energy in the form of heat, never producing a nuclear reaction. Indeed, we have observed the fusion reaction in the laboratory, but not as a source of energy production. Thus this does not achieve the goal of producing more energy than we put into a volume. To do that, we must obtain a hot mass of charged particles that can collide with one another and that are confined to a volume from which they can never escape until such time as they react with each other to produce energy.

Q. Since fusion requires a high temperature and in controlled fusion this temperature is obtained by accelerating particles to up to one-tenth the speed of light, how are you going to keep these particles from getting away from you?

A. You've put your finger on the most difficult problem in the whole fusion business. We call it containment. You see, particles which are moving at high speeds have very high energies and thereby have very high temperatures. No ordinary material can possibly contain such particles. (The temperatures, incidentally, are perhaps ten or a hundred million degrees.) The only possible way we can see at the present time of holding these particles together long enough to cause a fusion reaction is through a combination of magnetic fields. But unfortunately all the magnetic field combinations we have studied so far have the drawback of being unstable; that is, the magnetic container comes apart before the particles have been together long enough to react and thus to produce energy.

Q. How do you accelerate these hydrogen atoms to produce fusion energy?

A. First of all, we don't accelerate atoms. We use a collection of ions, usually deuteron. The deuteron is simply the nucleus of the heavy hydrogen atom with no electron. It therefore has a positive charge. By using this positive charge in some combination of electric and magnetic fields, we can heat the deuterons. Perhaps we heat them by squeezing them together. That's what the pinch machines attempt to do. Or else we accelerate them with a high-speed injector such as we use here in Oak Ridge in the DCX. In all, several techniques have been suggested for heating the ions.

Q. Each time that you talked about fusion reactions, you talked about the deuterium atom. What about the tritium atom? Is that ever used at all?

A. Tritium is by all odds the best nuclear fuel available. But for all practical purposes, tritium doesn't occur in nature — except as a curiosity. You have to manufacture it by making neutrons in a fusion reaction and capturing them in lithium. When you do that, the lithium atoms will convert to tritium. We suspect that once you get started, you can maintain your fuel supply. Tritium is a very frail material; it must be made artificially, and half of it disappears every eleven years. So you can't stockpile tritium.

Q. Would it ever be possible for us to sustain a thermonuclear reaction with ordinary hydrogen rather than deuterium and tritium?

A. It certainly is possible in principle. For instance, our sun's energy source is probably fusion of ordinary hydrogen, not deuterium.

Any light element, in principle, can be used as a fusion fuel. The details of the exact requirements for successful fusion are different with each possible combination of fuel materials. The easiest to achieve it with are deuterium and tritium. Hydrogen is next; lithium, beryllium are much more difficult and probably not very important because they aren't very plentiful. You see, hydrogen is the most abundant material in the universe, and so you'd naturally work on that first.

Q. Earlier you said that neutrons would escape the magnetic field. Well, how can you utilize them?

A. Let them strike something that will capture them, lithium being an example. And the only reason I put them into lithium is that when they're captured in lithium they make tritium, which can be put back into the reactor as a fuel material.

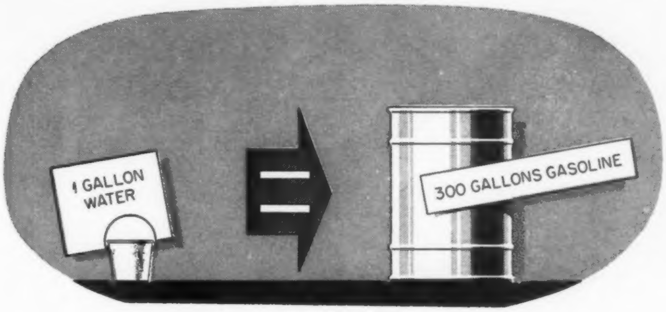
You could also catch them in U-235, making them produce fission and hence more neutrons, a process we call multiplication.

Q. You said that in these laboratory experiments you shoot one atom towards another — a target atom. How do you know if a reaction takes place? Is it by the temperature?

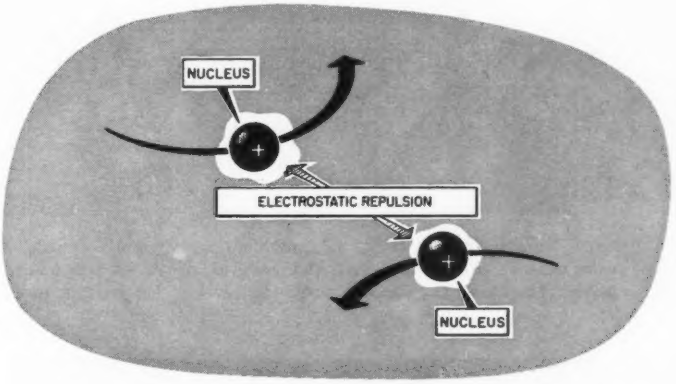
A. In a laboratory experiment, where all you seek to do is find the nuclear reaction, you take a target and you shoot a beam of atoms at it. This target can be heavy water or ice made from heavy water. Now all you have to do is look for neutrons. There are no neutrons at the beginning, but if a reaction takes place there will be neutrons produced. They'll be there someplace. So you locate a detector where the neutrons are supposed to be and look for the neutrons. You can tell the neutrons come from the reaction you're looking for by their direction and energy.

Q. Suppose fusion can be achieved. Would we then start using that energy for power in our homes?

A. I'd like to answer that question with another question. Assuming energy from atomic fission or from fusion can be made at a given price, will it be economically important at this price? The answer is, of course, that as we begin to run out of fuel — coal, gas, and oil — there will come a time when the price of conventional power will increase to the point where nuclear or thermonuclear power is cheaper. And so, in the not so distant future, you can expect to see central station power plants built on the basis of uranium fission. I hope I shall live to see a power plant built on the basis of deuterium fusion.

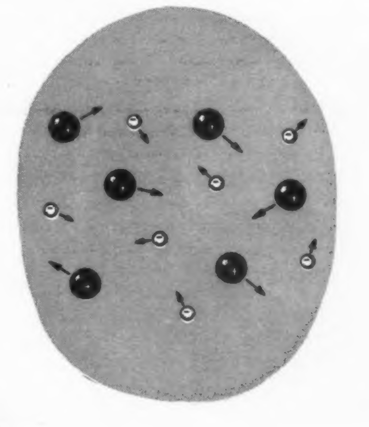


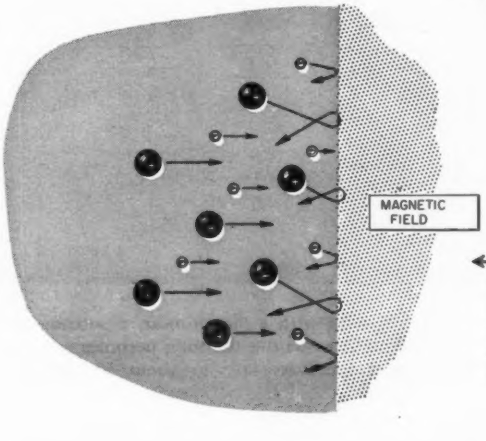
Thermonuclear energy that could be released from heavy hydrogen in gallon of water would equal energy of 300 gallons of gasoline.



All nuclei have a positive electric charge, thus tend to repel each other. Nuclei must collide with high energy to fuse.

Energy for fusion requires temperature of over 200 million degrees. Electrons then drift freely from orbits around nuclei. Resulting gas is called plasma.





Plasma at 200 million degrees would melt solid walls of container, so matterless walls provided by magnetic fields may be one answer.

By Ross E. Hutchins

INSECT SONGSTERS

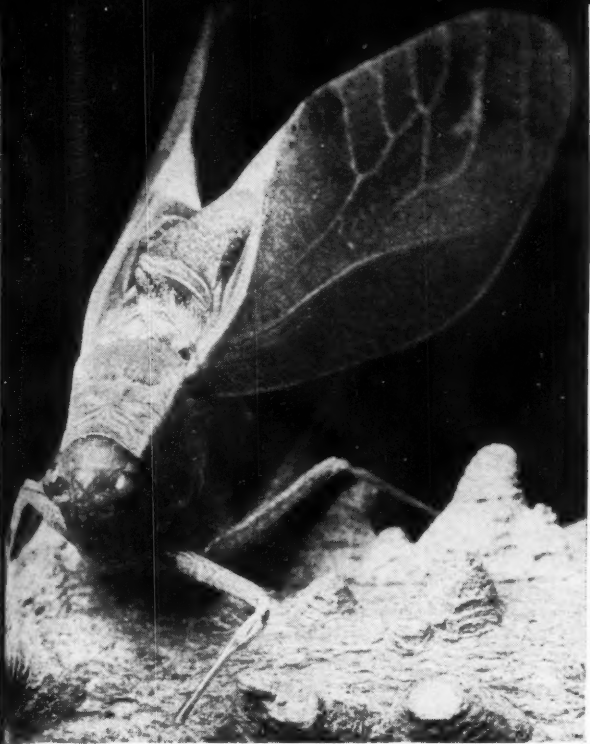
A noted entomologist-author takes a look at some of the insects whose songs and chirps are heard of a summer evening

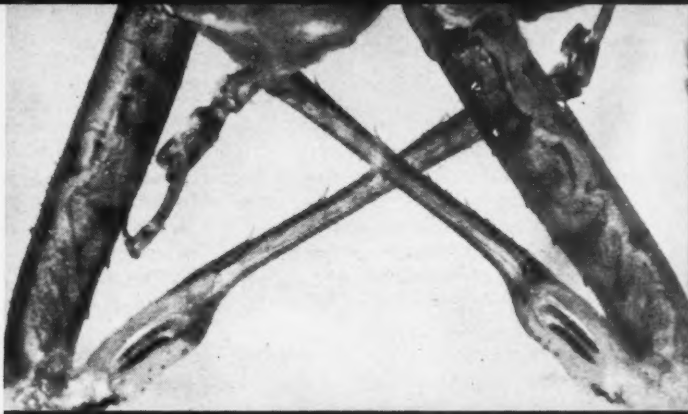
Photos by the author

MALE GREEN KATYDIDS begin their evening song with a monotonous repetition of 'kay-tee did it, kay-tee did it.' But as the night wears on, the song becomes a mere husky buzz and finally stops when the temperature falls to about 50 degrees.

■ Many birds and animals sing, but science does not always know just why. Sometimes the song or call of a wild creature is obviously a warning to other individuals of the same species to stay away — saying, in effect, "This area posted, no trespassing." In many other cases, the reasons why creatures sing are not so obvious. Probably it is often just a means of self-expression — like singing in the shower.

Many insects, too, express themselves in song. Here, again, biologists are not in complete agreement as to why they sing. Most crickets and katydids appear to have at least two kinds of songs. One is undoubtedly a mating call, but the other is apparently given just because the creature is alive and happy. The songs of these insects are just as much a part of their characters as is their coloration. The snowy tree cricket is an example of one of our most persistent songsters, sawing his fiddle all night long. He makes an average of about ninety chirps a minute, depending on the temperature, and it has been estimated that this adds up to more than two million chirps a month.





KATYDID SINGS by rubbing bases of wings together. *Above:* green katydid in typical singing pose. *Lower picture at right:* magnified view of green katydid's song-making instrument. Sharp scraper (*right*) on base of one wing is drawn back and forth across toothed rasp (*left*) on other wing. *Upper picture:* katydid's ears are near front elbows.

This represents a tremendous amount of effort on the cricket's part, and the strange thing is that we still do not know much about the reasons why he goes to all the trouble to saw out his tunes so enthusiastically.

Actually, no insect has a true "voice." They are all "instrumentalists" — their calls or songs being made by rasping one part of the body against another part. The crickets and katydids probably have the most elaborate sound-making apparatus of any insects. It consists of a series of teeth along the base of one wing and of a blade or scraper on the other wing. In the case of the katydids, the teeth are on the left wing and the scraper is on the right wing; some crickets have the teeth on the right wing. When one of these insects is ready to sing, the wings are raised and sawed back and forth, causing the blade on one wing to rasp across the row of teeth on the other. This manner of sound production is called *stridulation*, and it is the method used by almost all insects.

In the case of the katydids, at least, there is a thin expanded area near the base of each wing, and these act like drumheads in greatly increasing the volume of sound produced. This accounts for the fact that these small creatures are able to make noises out of all proportion to their sizes. The carrying power of some of these insect songs is truly amazing. Strangely, too, these insects seem gifted with the ability to "throw" their voices like ventriloquists. A cricket or a katydid never seems to be where the sound appears to come from, which is probably an advantage to the songster in escaping its enemies.

It is interesting to note that the names for these insects, katydids and crickets, are onomatopoeic — derived from the sounds they make. The katydid sings "katydid" and some kinds of crickets sing "kreekit." (The chickadee and bobwhite also have onomatopoeic names.)

Scientists have been investigating the sounds made by insects for a number of years. Among other things, they've discovered that we hear only part of insect songs. Many insects make sounds at high frequencies that extend far beyond the range of human hearing (about 20,000 vibrations per second). Also, recent research has shown that, while the males certainly have by far the louder voices, some female crickets are able to give muted chirps, probably in response.

So far, we've said nothing about the cicadas — seventeen-year locusts — and their relatives, but these insects, too, are concert singers of renown. However, their concerts are rendered during the day when the sun is hot. They never sing at night, and their method of sound production is entirely different from that employed by the crickets and katydids. Cicadas have two drumheads, or *tymbals*, located upon the lower surface of the body. The insect makes its sound, not by striking these drums, but by causing them to snap in and out by means of a muscle attached to their inside surfaces. In some kinds of cicadas, the drumheads on the two sides of the body vibrate alternately, resulting in a high-pitched sound. During summers when cicadas are abundant, a walk through a patch of woods where these insects are holding a concert is an almost ear-splitting experience.

Biologists have known for a long while that the chirp rate of crickets and katydids was influenced by temperature, being rapid in warm weather and slower in cool weather. Since all insects are cold blooded, their body processes are governed by outside temperatures. When the weather is hot, they are very active; but as the temperature drops, they become more and more sluggish until, at last, they do not move at all. Interestingly, it has been found that both crickets and katydids are so sensitive to temperature changes that the temperature can be very accurately determined simply by counting the number of chirps in a given length of time. With a simple mathematical formula and a watch with a second hand, you can figure out the temperature yourself.

The common black field cricket is a good one to experiment with. (His chirps sound like "treet-treet" to some people and like "cree-cree" to others.) After you have located a singing cricket, look at your watch, count the number of chirps he gives in 14 seconds, and add 40. The result will be very close to the correct temperature. For example:

No. chirps in 14 seconds	30
Add	40
Temperature is	70°F.

It is suggested that you make several counts and take the average. Since crickets usually become silent at temperatures below 50 degrees, the experiment will work only on warm nights.

The snowy tree cricket is another songster whose chirp rate can be used for temperature determination. As a matter of fact, this small green cricket is often called the "temperature cricket." To determine temperature from him, go through the same procedure as with his cousin the field cricket, but add 42 to the chirp count instead of 40. The temperature cricket is a good one to use, because his fiddle can be heard almost every night during the summer. His call, also, is something like "treet-treet-treet."

Temperatures can also be determined by counting the number of chirps that one of these crickets makes in 10 seconds and then looking up the correct temperature on the thermometer chart below.

The songs of katydids can sometimes be used to determine temperatures, but for one reason or another they are not as satisfactory as the two kinds of crickets discussed above. The large green katydid, often called the "true katydid," usually begins his song at dusk. If the temperature is 77 degrees or higher, it sounds like "kay-tee did it!" As the evening temperature slowly drops, however, he gradually shortens his accusing song, until he at last becomes silent at about 55 degrees. The female katydid, of course, never has a chance to defend herself against whatever it was she is supposed to have done, because she has no voice.

The insect choristers are found in many lands, but it was the Chinese who first regarded them as musicians of repute. More than a thousand years ago, in the ancient Chinese empire, it is said that the ladies of the royal palace often captured cricket songsters and kept them in tiny golden cages for their music. In time it was also found that the crickets could be induced to fight each other like tiny gladiators. The result was that they were often bred for their fighting ability. These thoroughbred crickets were given the finest care. In summer the pampered songsters and gladiators were fed upon cucumber and lettuce; during winter their diet was changed to chestnuts and yellow beans, with the addition of honey as a tonic. In summer they were kept in pottery containers with perforated lids. During winter, they were housed in gourd cages with beautifully carved lids of jade, ivory, or wood.

Cicada sings during the hot part of the day; unlike the katydids, it never sings at night. Drumlike organs on the underside of its body are its song-making apparatus.

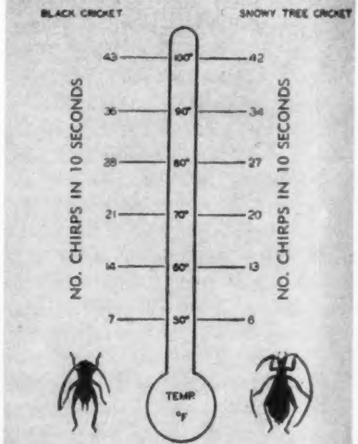


Chart shows how you can estimate temperature by counting cricket chirps.

By Eliot Tozer

New weapon against polio

■ On April 12, 1955, the world learned of a momentous advance in the war against disease. A vaccine had been discovered that could effectively combat polio, the dreaded crippler and killer. Tests on half a million school children had proved it 80 to 90 per cent effective.

The new medical weapon was, of course, Salk vaccine. And time has proved its worth. Since 1955, when the vaccine was first widely used, polio cases in the United States have dropped some 75 to 80 per cent.

Nevertheless, scientists haven't been satisfied. Would it be possible, they wondered, to make an even more effective vaccine? One that would take effect more quickly and produce longer immunity? One that would be easier to make and less expensive?

Now it appears that the answer to those questions is yes. Dr. Hilary Koprowski, Research Director of Wistar Institute in Philadelphia, recently reported on just such a vaccine. It is a one-dose vaccine that is swallowed in liquid form. When a person has drunk the liquid and become immune to polio, his immunity may spread to other members of his family.

Unlike the Salk vaccine, which is made of killed polio viruses, the new one contains living polio viruses that have been made harmless by forced growth in "foreign" hosts. The story of its development dates from 1948, several years before Dr. Jonas E. Salk started his vaccine work. The story has not yet ended — the vaccine is still being tested and is not yet available in the United States. But it looks now as though the new vaccine may one day eradicate polio.

Scientists at Lederle Laboratories, the University of Cincinnati, and Wistar Institute were chiefly responsible for the work that resulted in the live-virus vaccine. To appreciate the difficulties they faced, we must take a look into the strange world of the viruses. Viruses are simple organisms, so tiny they cannot be seen under an ordinary microscope. They are hard to study because they live inside their host cells. There, they reproduce like living things. But when removed from the cells, viruses cease to reproduce. Then, when attached to new hosts, viruses begin to multiply again. Viruses are now known to cause many diseases: chicken pox, smallpox, measles, mumps, and colds, to name a few. And researchers are finding a half-dozen new viruses a year. In fact, they are discovering viruses faster than doctors can match them to the diseases they cause.

Although the big viruses are only 1/83,000 of an inch in diameter and the little ones about 1/2,500,000 of an inch, scientists recently took some apart. The viruses consisted of an outside "shell" of protein and a "filler" of nucleic acid. Here, as nearly as scientists can guess, is how this tiny two-part organism attacks our bodies:

Carried by air or in human wastes, the virus enters the body, sometimes through the mouth. In the body, the virus is attracted to a host cell in which it can reproduce. It attaches itself to the host — a mass much larger than itself — and shoots nucleic acid into the cell.

For a time, all seems quiet. But inside the host cell, theorize scientists, chaos reigns. The host no longer produces its own protein and nucleic acid. Instead, it begins making virus protein and acid.

Suddenly, the host, exhausted by the production of virus protein and acid, collapses. Scores of new viruses are spewed out. In time, billions of new viruses may race out into the blood stream. (If the attacker is a particular one of the polio viruses, it may affect the central nervous system, causing the victim to suffer paralysis.) When the viruses enter the blood stream, the simple infection may have become a full-blown disease.

But the human body, in a wondrous way not yet fully understood, has meanwhile marshaled a defense force in the form of antibodies. These substances, produced by the lymphoid tissues, battle the invader and are often able to neutralize it. If enough antibodies are formed, the victim may not suffer more than a headache or a sore throat. He then becomes immune to the disease for as long as the antibodies remain in the blood stream, which is sometimes for years.

The purpose of a vaccine is to trigger the body's defenses and build up an army of antibodies to make the person immune without actually bringing on a disease. There are two ways this can be achieved:

Had your polio shots yet?

The Salk vaccine is still the only weapon available in the U.S. that can protect you from the crippling effects of polio. If you have not already had all of your Salk shots, be sure to get them now.

1. Doctors can inject viruses that have been killed — usually by formalin or heat. Certain viruses, even though dead, can stimulate the production of antibodies. Salk vaccine, for example, is made by growing polio virus in monkey-kidney tissue and then killing it with formalin, a solution of formaldehyde.

2. Doctors can feed patients live viruses that have been made non-infectious by "passing them through" — forcing them to grow in — a series of "unnatural" hosts, a technique first developed by Louis Pasteur. Because a virus is a parasite, it is fundamentally altered in "foreign" hosts. No one can predict in advance, however, just how a virus will be changed. Many tests must be conducted to discover what hosts will make it lose its power to infect.

The virus in Lederle Laboratories' polio vaccine, Orimune, was first grown in adult white mice, animals that do not normally harbor polio virus. The changed virus was then successively passed through 157 generations of newborn hamsters, losing at each step more of its virulence. Its power to infect was further reduced by adapting the strain to grow in chick embryos and passing it successively through 17 of those hosts. Finally, it was purified in monkey-kidney tissue. Even though it had been altered and weakened by these "passages," it could still multiply its numbers and could trigger off antibody production in the human body.

Dr. Koprowski at Wistar points out that modified live viruses stimulate antibody production in a way that "more closely imitates nature" and thus can provide a better chance of immunity than that given by the killed-virus Salk vaccine. Recent figures would seem to prove him right.

Also, Dr. Albert Sabin of the University of Cincinnati points out that Salk vaccine grants only local immunity. Even when some children have been given four doses of Salk vaccine, he says, it has "failed to influence in any way the extent of the multiplication of polio viruses in the intestinal tract, although multiplication in the throat was apparently prevented." He goes on to say, "The viruses in the throat are of little or no importance in the transmission of infection to others." For polio is spread through the anal-oral route: virulent viruses multiply in the intestine of the carrier and are excreted; in time some of these viruses may be ingested by a human. Salk vaccine apparently stimulates the production of antibodies in the blood, but does not prevent polio viruses from multiplying in the intestine. Although it may effectively prevent the disease, it cannot prevent the vaccinee from becoming infected, excreting the virus, and infecting others.

Live-virus vaccine, on the other hand, is taken orally. The modified viruses go directly to the intestine. There they stimulate production of antibodies that neutralize any viruses that come into the intestine. Thus, no infectious viruses are excreted.

Interestingly enough, says Dr. Koprowski, when modified viruses are excreted, they also immunize any person who ingests them. In an experiment at Moorestown, New Jersey, he fed live-virus vaccine to one child in each of eighteen volunteer families. Within a few days, examination of blood specimens showed a high antibody level in many other family members. In an unusual reverse twist, the live-virus vaccine had produced an "epidemic of immunity."

Since the vaccine goes directly to the intestine — where viruses spawn — it can work fast enough to stop polio epidemics. During recent outbreaks in Colombia and Nicaragua, not one person who was given the Lederle vaccine, Orimune, contracted the disease. After fast one-shot administration of Wistar's Type I vaccine in four ravaged areas of the Belgian Congo recently, no more cases of paralysis were reported. In contrast, it takes a year to administer the four-shot Salk vaccine.

How long will immunity last? It is too early to tell. But immunity generated by live-virus vaccine will probably last longer than that created by the Salk killed-virus vaccine. The reason is that live viruses multiply in the body, forcing it to produce more and more antibodies. Since killed viruses do not multiply, their antibody production is limited. This is also the reason why only one dose of the live-virus vaccine is needed, in contrast to four Salk shots. Dr. Koprowski reports that live-virus vaccine, which he first administered to a child on February 27, 1950, has provided immunity for nine years and may well give lifetime immunity.

The live-virus vaccine is not perfect; no vaccine can immunize everybody. And some scientists think there is a faint possibility that the modified virus, in passing naturally from one human being to the next, might suddenly regain its virulence. In fact, the World Health Organization is distinctly concerned about the million or more live-virus doses that have been given to natives of Europe, Africa, and South America in experiments conducted by U.S. scientists. (These countries were selected for mass testing because their populations had not developed widespread immunity to polio through the use of Salk vaccine.)

But Dr. Koprowski snorts, "The reversion to virulence theory is a myth. We have successfully vaccinated animals for years with live-virus vaccine — with no reversion."

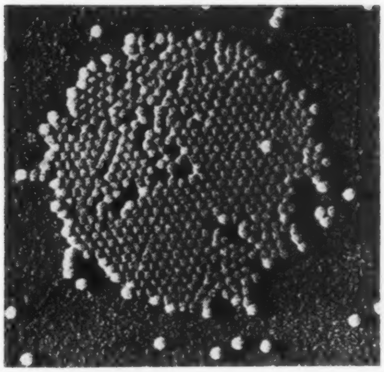
Lederle reports, "In not one case of the thousands on record has there been an altering toward virulence of the live viruses after they have been administered."

Meanwhile, under the auspices of the Pan American Health Organization, Lederle is giving vaccine to 400,000 more persons in Uruguay and Costa Rica this year. Vaccine grown under Dr. Sabin's direction is serving as "seed" to produce 10 million doses of live-virus vaccine for Russians; and Dr. Koprowski is preparing to bring the total of vaccinees in the Belgian Congo to 500,000.

Out of all these tests will undoubtedly come a safe, effective, long-lasting, and inexpensive vaccine — a vaccine that can be swallowed in one quick, pleasant dose.

This is the final spring issue of SW. Next issue: Sept. 1959.

Dr. Albert Sabin, one of the scientists responsible for developing the new polio vaccine, and Al, his pet chimpanzee.



Polio virus enlarged 58,000 times under electron microscope. Viruses multiply inside a living cell, but stop multiplying when removed from the cell.

— Wide World photo

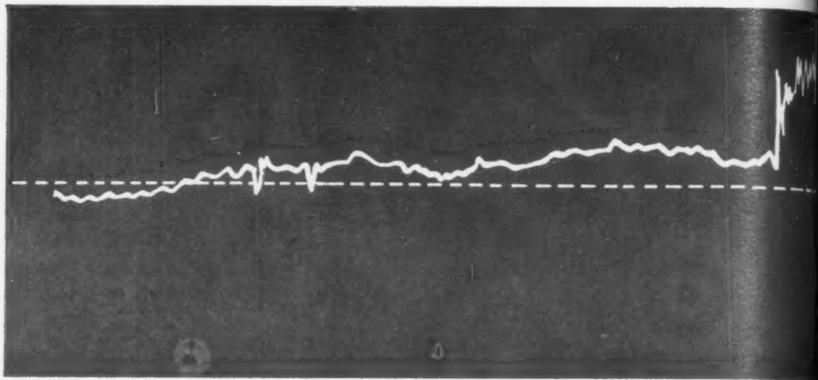
— Photo from Wistar Institute

Dr. Hilary Koprowski first gave his live-virus vaccine to a child in 1950. The child is still immune to polio today.

— Photo from Wistar Institute

Dr. Koprowski (*seated, left*) tested vaccine in Africa, where the population had no acquired polio immunity

THE SUBTLE STORM



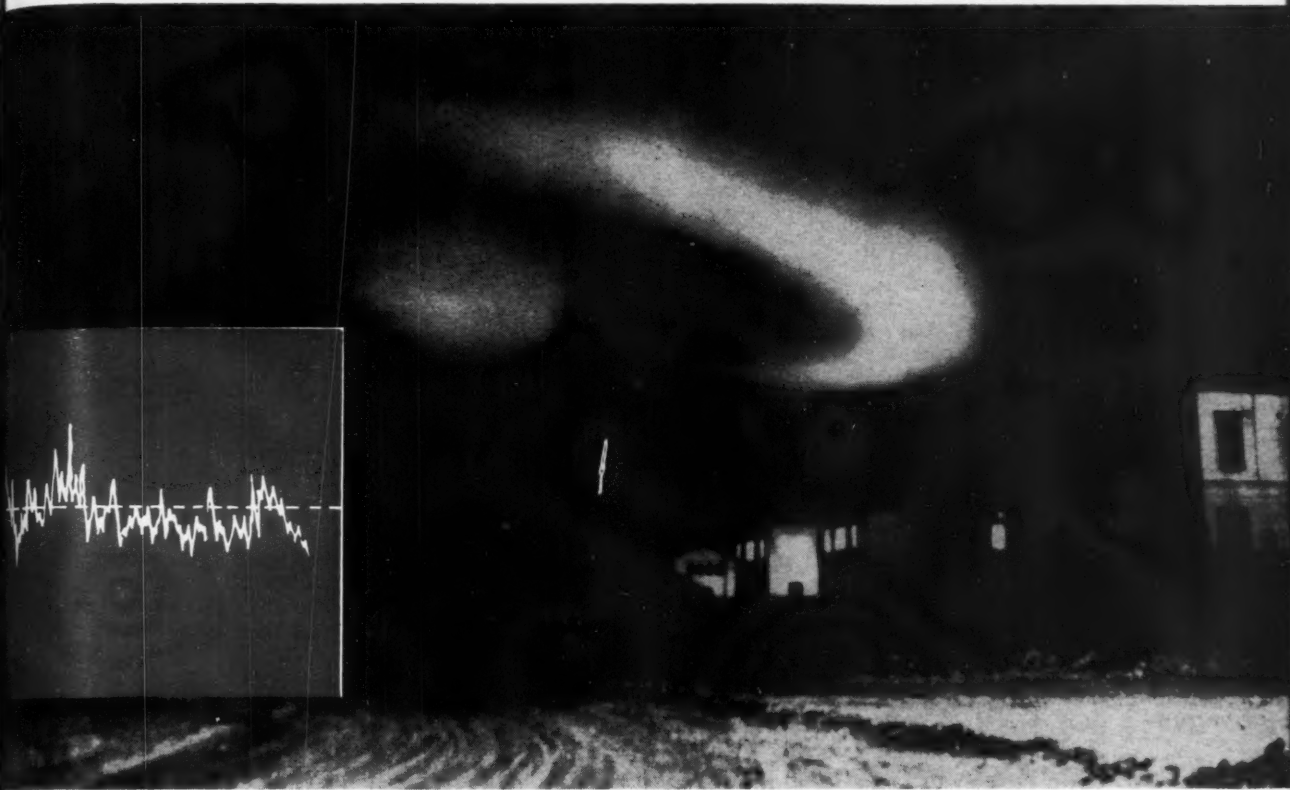
By John Brooks

On February 9, 1958, a solar flare erupted, marking the start of what turned out to be one of the greatest magnetic storms on record. Magnetic storms are little-understood terrestrial disturbances that send compasses haywire, cause auroras, and disrupt radio communications. In this article, the last of three parts, the author describes the effect of the February, 1958, storm on the earth.

PART III ■ At that instant, the horizontal-component trace on the magnetograph at Fredericksburg suddenly jumped five hundred gammas. The comparable increase at Fairbanks, Alaska, couldn't be measured, because the needle went right off the page; conservatively estimated, it was several thousand gammas. Within the next minute, not only the A.T. & T. and *Times* circuits but all other direct radio circuits between the United States and Europe faded abruptly into silence. Companies that had relay stations to the south, set up there to circumvent encroaching auroras by detouring signals through the magnetically calmer tropics, began to try to use them; R.C.A. Communications, for example, found that it could keep spottily in touch with London and Paris by transmitting to Tangier and having Tangier pass its messages on back north. The aurora now rose so sharply in intensity that it could be seen even in New York City, whose bright lights and smoke make it one of the world's worst auroral observation points, even when the sky is clear, as it was on the night of February 10th. As seen from the upper stories of local skyscrapers and from outlying hilltops, the aurora was a vivid combination of red rays and arcs stretching from the northern horizon nearly to the zenith.

At almost the exact moment when the magnetograph traces leaped and the aurora flared up, huge currents in the earth, induced by the heavenly turbulence, manifested themselves not only in power lines in Canada and the northern United States but in cables under the North Atlantic. In Newfoundland, voltage in electric circuits varied by as much as three hundred and twenty volts for half an hour or so. Circuit breakers began tripping out in Ontario transformer stations, plunging the Toronto area into a temporary darkness broken only by the strange light of the aurora overhead. In western Minnesota, the Dakotas, and eastern Montana, which are closer to the auroral zone than any other parts of the United States (except, now, Alaska), the effect on the Missouri River Basin Project power system was — as its operations officer, F. W. Lachicotte, later put it, in a report — "startling." The consumers in the area saw nothing more than a flicker or two in their lamps, but the men operating the system, practically none of whom had had any previous encounters with a magnetic storm, were amazed at what was going on backstage; some unseen hand seemed to have taken charge of their equipment, causing violent fluctuations of voltage, which brought the automatic regulators clicking into operation to compensate. "The activity . . . seemed to rise suddenly from a quiescent period to a maximum, then subsided slowly," Lachicotte wrote. "The process by which aurora borealis phe-

— Photo from Amer. Museum of Natural History



AURORAS, like this one over Alaska, heralded the storm's presence, which was confirmed by jump in magnetograph tracing.

nomena affect power systems is unknown in this office," he added, taking the auroral symptom for the storm itself. As far as that goes, however, the process is also unknown, or imperfectly understood, everywhere else.

At one minute after nine, Western Union began to experience serious interruptions on its nine North Atlantic telegraph cables. As for the Bell System's North Atlantic telephone cable, service was never entirely disrupted, but it was on this cable, which runs between Clarenville, Newfoundland, and Oban, Scotland, that undoubtedly the highest and most dangerous of all the abnormal voltages induced by the storm appeared. Everything was working smoothly until two minutes after nine, but then the magnetic storm suddenly converted the whole North Atlantic into a gigantic battery packing a potential of two thousand six hundred and fifty volts. The effect of this supercharged condition on the cable was to weaken the signal strength going eastward, and, while the surge lasted, American telephone voices came through to Europe sometimes in whispers and sometimes in loud squawks. The westbound signal strength remained normal, because voltage regulators at Clarenville and Oban were able to absorb the jolt. The Bell engineers had cause to be grateful for the sturdy resilience of their equipment; they had never before seen anything like such an induced current in the North Atlantic cable, they said later, and they would be just as happy not to see one again. If it had been much bigger, it might have done tremendous damage.

Fortunately for the nerves of power and communications men, and for their equipment, the surges were short-lived. The North Atlantic battery burned itself out in less than ten minutes, and conditions in the telephone cable returned to near normal. The earth currents in Canada and the North Central States were petering out by nine-forty, and by ten o'clock the Western Union telegraph cable was working again, though too shakily to handle anything like maximum traffic. Meanwhile, the radio situation was steadily getting worse. The effects of magnetic disturbances on radio are always most severe at night (sunlight seems to stabilize the ionosphere), and in the raging storm one connection after another was broken. A.T. & T. lost radio contact with South America at nine-forty-five, and at ten R.C.A.'s Tangier relay station faded out. R.C.A. managed to push messages through to Europe for a while longer, by way of a station even farther south, in Paramaribo, Surinam, but this, like the frantic measures that various competing radiogram companies resorted to, was only a stopgap, designed to postpone as long as possible the moment when the damage to the ionosphere would be so widespread and so extreme as to cause a total North Atlantic blackout. Almost on the dot of eleven o'clock, R.C.A. in New York heard Paramaribo become fluttery and then faint. An instant later, it was silent. The blackout was complete, and during the next hour and a half, except for the still unreliable cables, which were hopelessly choked with backed-up messages, the Old World and the New were in scarcely better

touch than they had been in the days of the clipper ships.

All this time, the overseas airlines were in a frightful stew. Their ground-to-ground transatlantic radio circuits, on which they rely for such urgent matters as flight-dispatching and landing-weather information, as well as for all messages concerning supplies, reservations, and administrative affairs, were utterly useless. The bare, essential minimum of information now had to be diverted to the cables, scarcely usable themselves. And the air-to-ground communication situation was almost as bad. That night, as on almost any other night, there were at least a hundred airplanes groping their way, in one direction or the other, across the North Atlantic. For the sake of their passengers' safety, as well as their own peace of mind, the pilots of these planes were supposed to keep in continuous radio contact with one or another of the stations in the North Atlantic aircraft network — the one on Long Island, or one of those in Newfoundland, Iceland, Ireland, London, and the Azores. The pilots had no trouble as long as they were near enough to a station to be on a line of sight with its transmitter, but when they got out so far that the hump of the earth intervened, they lost contact; their old friend the ionosphere had gone all to pieces. Then the pilots began using other aircraft, nearer a ground base, as relay stations, and all night long the radio air buzzed with the sound of urgent voices relaying messages. In parts of the world less amply endowed with convenient ground stations and hospitable fellow-travelers, airmen had to go it alone. The captain of a passenger-laden Air Force plane that was already well on its way from New Zealand to Antarctica when the magnetic storm struck decided to press on, rather than turn back, and completed the two-thousand-mile haul over pack ice and frigid water without being in radio contact with anyone.

Between 1:00 and 2:00 A.M., New York time, the force of the storm abruptly declined. The Fredericksburg horizontal-component trace, which had been fluctuating within a range of more than two thousand gammas for several hours, and the magnetic-declination trace, which had been wavering more than two and a half degrees, both calmed down considerably. As it happens, a particularly interesting part of a storm to most scientists is the few minutes in which magnetic activity begins to fall off sharply, and, during the several hours that this one had been going full blast, the IGY scientists had plenty of time to hear all about it and to put their instruments into operation, so, even though no Special World Interval had been declared, they were ready for the big moment. Dr. J. R. Winckler of the University of Minnesota, who specializes in the measurement of various atmospheric phenomena by means of instruments sent up in balloons, managed to get one of his equipment-laden gasbags up some twenty miles above Minneapolis before the magnetic decline began, and while it was on the instruments recorded an unusual burst of X rays. At the same instant, instruments at Boulder were recording a striking decrease in the amount of radio noise coming from the stars. Such findings as these, while not subject to quick interpretation or readily related to magnetic disturbances, provide clues of just the sort that the geophysicists need for future study of what magnetic storms are all about.

This is the final issue of SW for the spring semester. We'll see you again in September. Meanwhile, happy vacation!

As for the aurora, it was near its peak when the storm began to ebb. With the United States in darkness from coast to coast, it could now be seen from just about anyplace where the sky wasn't covered with clouds, as well as from some places where it was. In the neighborhood of San Francisco, bright-red lights streamed across the top of a low cloud bank; in Washington, D.C., the northern sky seemed to be reflecting a huge forest fire; in Minneapolis, there were now flashes of blue interspersed with the earlier green and red. New York City, whose first display had faded three-quarters of an hour after it appeared, was given a second showing; while the color changed from red to blue-green, the illumination was brighter than it had been and reached higher into the sky. Ithaca remained cloudy, but Dr. Gartlein, at the Auroral Data Center, continued to gaze resolutely up at the clouds and still saw a red glow filtering through them.

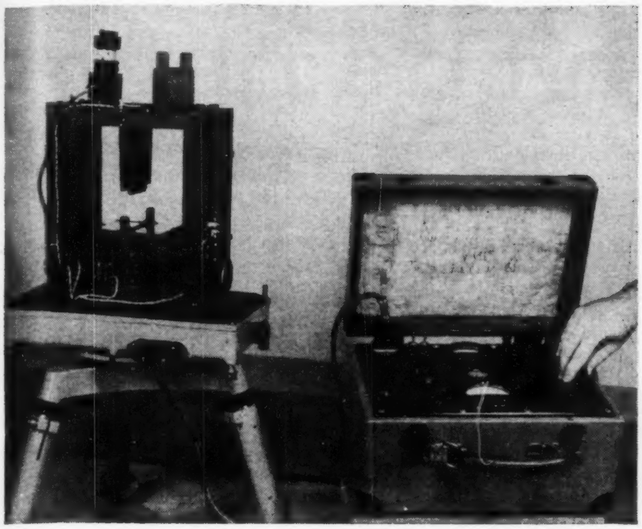
Before the storm ended, there were aurora reports from places as widely separated as Los Angeles, Tulsa, Havana, and the Eysk Marine Hydrometeorological Station, on the Sea of Azov, in Soviet Russia, but the one that probably testifies most eloquently to the extent of the night's display was from a ship in a latitude where auroras are practically unheard of. Just at midnight — 2:00 A.M. in New York — the S.S. *President Taylor* was off the west coast of Mexico a little north of Acapulco and only eighteen degrees above the equator, when her junior third officer, H. K. Pyles, noticed that the northern horizon was inexplicably illuminated by a deep-red glow, so intense as to be reflected on the sea's surface. If Mr. Pyles knew that he was recording one of the most southerly appearances of the northern aurora in history, he did not mention the fact in the brief, unemotional entry he made in the ship's logbook.

At half-past four, Dr. Gartlein took a last glum look at the stubborn reddish clouds over Ithaca, switched on his automatic sky camera, to keep the record intact, and flopped into bed. Two hours later, his wife got up and took over the vigil. The sky, she reported to her husband, had a rosy, auroral cast until the very last moment before dawn.

In the North Atlantic, as at Ithaca, the wild night ended with sunrise dimming and finally drowning the northern lights. As daylight moved westward across the United States, radio conditions improved rapidly. R.C.A., which had re-established sporadic contact with Paramaribo at one-thirty, and with Tangier an hour and a half later, now found its direct European circuits gradually coming back. A.T. & T. was back in radio touch with South America. The magnetic storm was not over — indeed, the Pacific, which was now mostly in darkness and therefore more susceptible, began to lose its radio circuits — but it was certainly past its peak. Even so, early on the morning of Tuesday, the eleventh, the Coast and Geodetic magnetic station at Tucson sent out a general warning to public and private geomagnetic prospectors — the men who hunt for oil with instruments that can spot a deposit by measuring the degree of magnetism of subterranean rock — that their scientific dowsers would be useless for the day, owing to disturbances in the earth's magnetic field. In New York City, the morning was clear, with the temperature in the low teens. The stock market opened lower. The Fredericksburg observatory noted at 10:00 A.M. that the major magnetic activity of the storm appeared to be past. There and elsewhere, on both sides of the Atlantic, scientists were beginning to rub their eyes and assess the damage.

In some ways, they discovered, the

— Official USNC-IGY photo



— Photo from U. of Minnesota

VARIATIONS IN EARTH'S MAGNETIC FIELD are recorded photographically by Askania earth variograph (*with cover removed*) and control box. Such instruments are located at various geomagnetic stations around the world. While the February, 1958, magnetic storm was going full blast, Dr. J. R. Winckler (*above*) of the University of Minnesota, atmospheric specialist, launched an instrument-laden balloon that recorded unusual X-ray activity.

effects had not been nearly as bad as they might have been. For one thing, telephone and telegraph service within the United States had been disrupted far less than in the great Easter storm of 1940; this seemed to be largely because of technical advances made during the intervening eighteen years, particularly in the shielding of cables. (The improvement was less marked in some European countries. The Dutch telegraph service was in trouble late Monday night, and in Sweden domestic communications were in such a mess that the government subsequently ordered the Stockholm Observatory to make an investigation.) The Associated Press found that its domestic teletype circuits, which operate on leased telephone lines, had been affected only briefly and spottily. As far as European news was concerned, the A.P. and other American news agencies could congratulate themselves on a couple of strokes of luck. For one, the storm had conveniently come at a time when there was no big news breaking in Europe; the radio blackout may have meant that America was a little late in getting word of negotiations toward a summit meeting, which never got anywhere anyhow, and of the death of Dr. Ernest Jones, the great psychiatrist and biographer of Freud, but for once there was no world crisis. The other lucky break was that the storm had begun so late — an hour and a half after midnight by London time — that most of the day's reports from Europe had been sent before the blackout curtain fell.

An irony of the storm was that it had given certain radio amateurs an opportunity to increase their communication range enormously. On the very high frequencies, one of the bands of wave lengths that amateur operators are allowed to use, transmissions that normally pierce right through the ionosphere, and are thus confined to line-of-sight range, will sometimes bounce back to earth when an aurora is present. They won't do this often enough for useful communication during magnetic storms, but they do it often enough to gladden the hearts of hams. A ham in Falls Church, Virginia, reported that during the night of February 10th he had heard Mississippi, Tennessee, Kentucky, Missouri, and Iowa coming in clearly, if sporadically, and a ham in Mississippi picked up Middletown, Rhode Island. All these contacts were established on a frequency band in which a fifty-mile connection is ordinarily considered good. Through the small hours of the morning, while the world's biggest communication systems were practically shut down, the magnetic storm was whimsically enabling men and boys in attics and back-yard shacks to communicate as they had seldom, if ever, communicated before.

The following night, auroras were again seen in a good many places, and radio communication was erratic over the North Atlantic, but the storm was unmistakably on the wane. The magnetograph readings at Fredericksburg now looked like low shrubs, rather than towering firs. By sunrise on February 12th, they resembled the easy undulations of desert sands. The cosmic cloud, it seemed, was passing off into space. At 10:00 A.M. on the twelfth, Coast and Geodetic declared the storm officially over. At the same hour, the stubbornly oblivious New York stock market opened lower again. The temperature in New York City was twenty-six, and the sky was cloudy.

Happily for separated lovers everywhere, the magnetic storm had ended in time to permit the unimpeded transmission of cabled, radioed, and telegraphed St. Valentine's Day messages, whether from Cape Town to Sitka, Tierra del Fuego to Vladivostok, or Amsterdam to Stockholm. Furthermore, with the sunspot peak safely past, it seemed likely (and now seems even more likely) that there would be no magnetic storms as violent as that one until the next peak. For what comfort it may bring the inhabitants of a planet subject to a variety of natural and unnatural shocks, the sun probably won't deal the earth a blow as jolting as this until 1967, at least.

Science in the news

Cover story

A "paddle-wheel" satellite is scheduled to be launched into an earth-circling orbit, perhaps sometime this month. (See *SW*'s front cover.) If the satellite performs successfully, a similar vehicle may be used in probes to Venus and other planets.

One of the major problems of sending a probe to Venus is this: a continuing source of electricity must be provided to power the probe's instruments and radio transmitter. Unless data can be radioed back to the earth, a probe has little point. The paddle-wheel satellite may help solve this problem.

The paddles, originally folded inside the satellite, will pop out when the satellite swings into orbit around the earth. In the paddles will be photoelectric cells. These will convert sunlight into electricity. The electricity will recharge ordinary chemical batteries in the satellite's sphere. The advantages of putting the photo cells in the paddles are these: (1) a larger surface area of the cells can be exposed to the sun, which means more electricity will be generated; (2) the paddles can be so positioned that the photo cells in at least one paddle will always catch the sun's light.

If the paddle-wheel satellite proves immediately successful, a paddle-wheel probe may be sent to Venus on June 9, when the planet is in a favorable position in relation to the earth. If the experiment fails or if more tests need to be made, the Venus shot will come later. Two Venus probes are now being planned by the National Aeronautics and Space Administration. In one, a 75-pound payload is to be fired by a Thor-Able rocket to the vicinity of Venus. In the other, a 325-pound payload is to be launched by an Atlas-Able missile into an orbit around Venus.

Powerful radio waves fatal to monkeys

An experiment with monkeys and radio waves in a National Institutes of Health laboratory at Bethesda, Maryland, brought this unexpected result: ten monkeys died soon after they were exposed to ultra-high-frequency radio waves. The waves had been beamed at each monkey's brain stem, the central and most vital part of the brain.

Recent experiments in New England have proved that radio waves in the medium-frequency range can influence the behavior of living cells (*SW*, April 21, page 18). But before the monkey test, there was no reason to believe that radio waves could affect the activity of the brain, even in a harmless way.

A scientist associated with the experiment emphasized that as far as is known the radio waves used in radio and television are not harmful to humans. The radio waves used in television are in the very-high-frequency range, which is a step below ultra high frequency. And the waves used in commercial radio broadcasts are in a much lower frequency bracket. In addition, the scientist pointed out, the position of a monkey's head in relation to the source of radio waves was an important factor in the waves' effect on the animals. In the experiment, the antenna of a radio transmitter was placed about two feet above a monkey's brain stem.

The results of the monkey experiment could be far-reaching, the scientist said. He suggested that radio waves might be useful in studying what happens to the brain when it is damaged and in performing psychological experiments.

Nuclear blast could test relativity theory

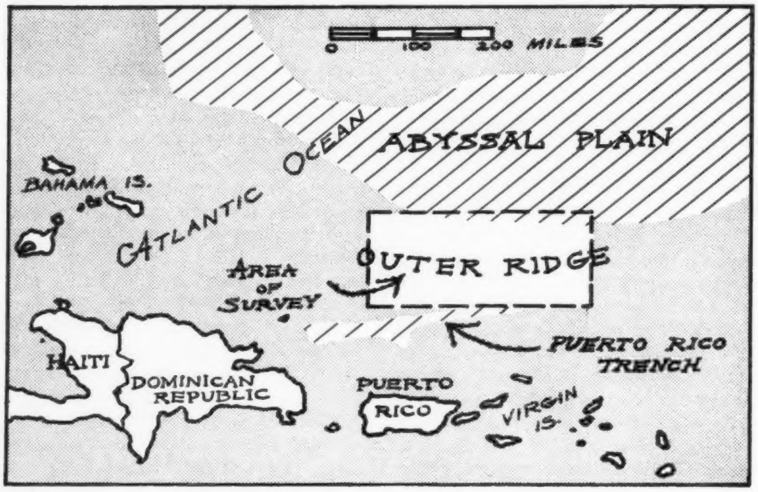
A noted physicist, Dr. Edward Teller, has described a way to test Einstein's theory of relativity: explode a nuclear weapon 100 million miles from the earth.

The relativity theory states that with one exception all the factors in the universe – including time, space, and mass – are continually changing. The exception is the speed of light, which remains constant at 186,000 miles per second. And, according to Einstein, in the near-vacuum of space all types of electromagnetic radiation (radio waves and X rays, for example) travel at the speed of light.

To test this theory, Dr. Teller suggests the following: Launch a powerful nuclear charge by rocket into an orbit around the sun. When the charge is 100 million miles from the earth, set it off by radio signals from a ground station or by a special timing device. The blast will give off various kinds of radiation. Measure the time it takes for each kind of radiation to reach the earth.

If the relativity theory is correct, all radiation will make the trip in the same time. But if X rays and light waves, for example, race to the earth at different speeds, the theory is not valid.

Drawing by Wes McKeown



A hole several miles deep will be drilled in the ocean floor. Scientists will explore the rectangular area shown, north of Puerto Rico, to find a drilling site. They hope to bore through the Moho (Mohorovicic Discontinuity), the lower boundary of earth's crust. The crust is thin in this area, the water relatively shallow. The 'Mohole' should yield clues to the earth's composition.

Craft being developed to skim land or sea

Automobiles, trains, and even ocean liners may one day skim over land or sea. Vehicles are now being developed or tested (by the armed forces and private industry) that fly at heights of from a fraction of an inch to 50 feet. They operate by a revolutionary new means – the air cushion.

The air cushion works this way: Air under high pressure is shot through a nozzle toward the ground. This downward stream of air creates a "cushion" that lifts a vehicle off the ground. Once in the air, the craft can move horizontally by means of propellers, air vents, or jets.

Vehicles using the air-cushion principle are said to have more lifting capacity than helicopters, to travel faster than both helicopters and surface vehicles, and to be more maneuverable in many ways than present-day aircraft. Air-cushion craft now being developed or tested include:

- A flying tank that travels a few feet above the earth's surface at a top speed of 200 miles per hour. Tests of a one-ton model of this tank are planned this summer.
- A seagoing "flying saucer" that will fly at 20 to 50 feet above the ocean's surface at a high speed. Controlled by radio from a mother ship, it could be used to hunt submarines.
- A flying troop carrier, about to be tested, that can fly at about 50 feet above land or water.
- A flying train that will travel 300 miles per hour at one or two feet above a concrete roadbed shaped like an inverted V. This is in an early planning stage.
- A circular passenger ship, about 1,000 feet in diameter, that will travel 50 feet above the water at 175 miles an hour. This is still on the drawing board.
- A car that travels a fraction of an inch above the ground at speeds of from 200 to 500 miles an hour. An experimental model has been made (*SW*, February 24, page 18).

Snowstorm in wind tunnel aids defense effort

Scientists recently spent three hours watching a typical Greenland blizzard – in miniature. The "snowstorm," complete with swirling gusts and mounting drifts, was produced in a wind tunnel by researchers from New York University for the U.S. Army Corps of Engineers.

The scientists are trying to solve snowdrift-control problems on the Greenland icecap and in other polar regions. Knowledge gained from the wind-tunnel experiment will be used in building the Army's DEW (Distant Early Warning) radar defense line in Greenland.

In the wind tunnel were scale models of buildings. To make the "storm" more lifelike, the size and density of the "snowflakes" were scaled proportionately. Borax served as snow.

The scientists' next problem: to learn what structures will best withstand the contracting and swelling of permafrost (permanently frozen ground) and the erosion effects of snowdrifts.

Rich animal life found in deep-sea trenches

A new world of life is being probed by scientists. This is the world of the steep-sided trenches that cut deep into the ocean floor. The average depth of the ocean is about 2.5 miles. But in some trenches the sea bottom is from 4 to 7 miles below the ocean's surface. The pressure at such depths ranges up to 900 tons per square foot.

Because of such intense pressure, there was once doubt that life could exist in the trenches. But during the past eight years Danish and Russian scientists have hauled from the trenches a wide variety of marine animals. These included sea worms, sea cucumbers, deep-water mollusks, and barnacles. One Russian haul alone brought up some 1,000 specimens from a depth of 5.6 miles.

Oddly enough, the animals seem to thrive under the intense pressure. They are generally gigantic as compared to their shallower-water cousins. In fact, some leading oceanographers believe that monsters of sea-serpent dimensions may prowl the ocean depths. A deep-sea eel larva, for example, may be from four to five feet in length. Though the adult eel has never been seen, the size of the larva implies that the adult is of sea-serpent size.

Many creatures of the trenches are found nowhere else. And the same types of animals may be found in trenches thousands of miles apart. This suggests that at one time the animals migrated from one trench to another.

To date, studies of sea-trench life are rare, because specimens are difficult to collect. It's quite a feat to hit the bottom of a trench with a net lowered by miles of cable from a drifting, tossing ship. And, after the net has been dragged along the bottom and the specimens collected, it must be successfully hauled up. If it hits the side of the trench, the load may be lost.

News in brief

- The U.S. and Canada will jointly explore the ionosphere, an electrically charged layer in the earth's upper atmosphere. Disturbances in the ionosphere are believed to cause auroras (northern and southern lights) and radio blackouts. U.S.-made research rockets will be used to gather data on the ionosphere over the arctic, where auroral displays abound. Toward the end of 1960, the U.S. will launch a Canadian-designed satellite. This satellite will transmit radio signals toward the earth from above the ionosphere, while ground stations beam signals upward. By comparing the ionosphere's effect on the two sets of signals, scientists hope to learn more about the layer's structure and density.

- To most people, all onions smell the same. But to scientists who really know their onions, there's a definite difference in smells. Sensitive chemical instruments have revealed that the odors of no two onions are exactly alike. What's more, the odor of a single onion changes in composition every fifteen minutes or so.

- An atomic submarine that can launch the Polaris intermediate-range ballistic missile from above or below the surface of the water is nearing completion. Named the *George Washington*, the huge submarine weighs 6,700 tons when submerged. The 1,500-mile-range missile will be fired from vertical tubes in the sub. One of nine missile submarines planned by the U.S. government, the *George Washington* will be ready for operation in 1960.

- A botanist will study the brews made by African witch doctors, seeking "trade secrets" that may aid modern medical science. This is not as strange as it may seem. Plants first used by natives as medicines have in the past yielded chemicals of real use to doctors. Examples: reserpine (a tranquilizing drug) is derived from an Indian plant, snakeroot; cortisone (used in the treatment of rheumatoid arthritis) can be produced from the African stropanthus and the Mexican yam (as well as the adrenal glands of animals); and curare (used as a muscle relaxant) comes from the sap of a South American vine.

- The moon may be an active body with a hot interior and surface eruptions, according to Dr. Harold C. Urey, Nobel-Prize-winning chemist. His new theory supports a Russian astronomer's report of sighting a gaseous eruption. Previously, the moon was generally regarded as being inactive and cold.

Summer is an ideal time to start your project for next year's science fair. Otherwise, before you know what's happening, you may find that

SUDDENLY IT'S 1960

■ By the time you read this, 1959's science fair will probably have passed into history. For some of you the fair meant recognition for a job well done. For others it represented a fine learning experience. For yet others the fair was a door opening on the wonderful world of science. But for all of you, the end of one fair should mean that it's time to start thinking about the next one. The leisure of summer makes it an ideal time to explore the materials and ideas in the world about you and to start planning ahead. This is particularly true if you're contemplating a biology project.

To help you get started, here are some successful projects culled from 1959 science fairs. Perhaps one will suggest an interesting project for you.

Growth of pollen grains

Pollen grains will germinate in sugar solution, and their rapid growth is a remarkable thing to watch. A student drew on this for his project. He prepared cane-sugar solutions of concentrations varying from 2 per cent to 30 per cent. He built a collar of paraffin on a glass slide. He then placed on top of the collar a cover glass from the center of which hung a drop of sugar solution into which he had dusted some pollen. With a microscope, he watched the pollen grow. By experimenting with the pollen of narcissus, lily, daffodil, tulip, and sweet pea, he determined the optimum sugar concentration. He compared the growth in the artificial solution with the growth of pollen in the sticky exudate of the stigma.

Growing anaerobic bacteria

A boy interested in microbiology prepared cultures of anaerobic bacteria from samples of soil and dust by the following technique. He took up some of the material on the end of a sterile nichrome needle and stabbed it vertically into a tube of nutrient agar. He then covered the surface of the agar with melted sterile vaseline to exclude oxygen and incubated the tube.

In growing pure cultures, he used another technique. With the nichrome loop, he picked up some of the material from a colony in the previously prepared tube and transferred it by streaking over the surface of an agar slant in a test tube, which he plugged with cotton. He then placed 5 grams of dry pyrogallic acid in the bottom of a Mason jar. He poured 50 milliliters of 1 per cent sodium hydroxide over the pyrogallic acid and quickly placed the tube in the jar, and immediately screwed the cap of the Mason jar down tightly. The sodium hydroxide reacted with the pyrogallic acid, removing all the oxygen from the jar. When incubated for 24 hours, a pure culture of these bacteria appeared on the slant.

Effect of a weak electric current on a culture of protozoa

In a very interesting project, a student filled a small glass U-tube with a dense culture of paramecia. Two thin wires were connected to a dry cell, and the other end of each was placed in an arm of the tube. The wire ends just touched the surface of the liquid. The student observed the migration of the animalcules toward the negative terminal. He then reversed the connections and observed the reaction. After trying the experiment with other protozoa, he raised a question: Was this a true tropism, a reaction to the chemicals released at the electrodes? Or was it a result of an electrical charge on the surface of the organism? He plans to devise an experiment to determine which of his hypotheses is correct. This could well form the basis of his next year's project.

Measuring the rate of growth of a plant

The auxanometer shown in Fig. 4 was used to compare the vertical growth of plants under various growing conditions. It involves a pulley to which is bolted a pointer cut from a thin sheet of aluminum. One end of the string going through the pulley is tied to the top end of the plant. A weight that will keep tension on the string is tied to the other end. The scale can be marked off into units so that the pointer will indicate how many units the plant has grown in a given length of time.

Inheritance of family traits

Physical characteristics such as eye color, stature, longevity, hair color, color blindness, extra fingers, albinism, cataracts, and so on, are thought to have a hereditary base. A study of some one characteristic within your own family can be extremely interesting. One student did a fascinating study of the heredity of the hair pattern on the second joint of the middle finger. Another employed "tasting

Fig. 1:
A homemade hanging drop slide for observing the germination of pollen grains in sugar solution

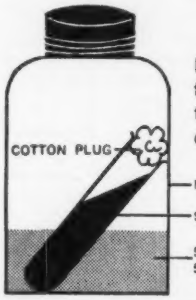


Fig. 2: Method of culturing anaerobic bacteria in atmosphere devoid of oxygen

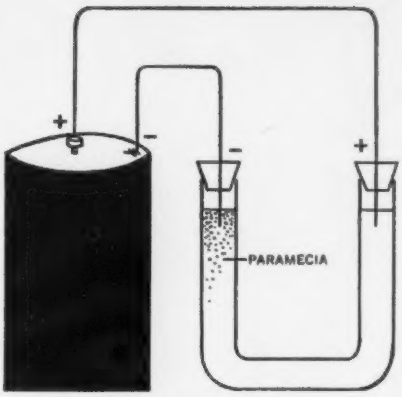


Fig. 3: An experiment in galvanotropism

paper," a paper impregnated with the chemical phenylthiocarbamide. To some people this chemical tastes bitter; others find it tasteless. By trying the "tasting paper" on members of a family, this student determined whether "non-tasting" acted as a dominant or recessive trait.

The topography of taste

Another young scientist — a girl, this time — made up solutions of cane sugar, quinine, sodium chloride, and acetic acid. She tested the tip, sides, back, and middle of the tongue with each solution. For this she used a camel's hair brush dipped in each of the solutions. The subject did not know what solution was being tested. With the results of the experiment, she mapped the areas of the tongue that specialized in the sensations of sweetness, bitterness, saltiness, and sourness.

Effect of nitrogen-fixing bacteria on the development of bean plants

A student filled six flower pots with poor soil and heated them in an oven for two hours at 350° F. Then he disinfected eighteen bean seeds by soaking them for one hour in weak formalin. After washing the seeds in sterile water, he planted three in each pot. He then inoculated three of the pots with a culture of nitrogen-fixing bacteria obtained from the state college of agriculture. The other three pots served as controls. All six plants were given only distilled water. After the plants had grown one or two feet high,

[*Continued on p. 23*]

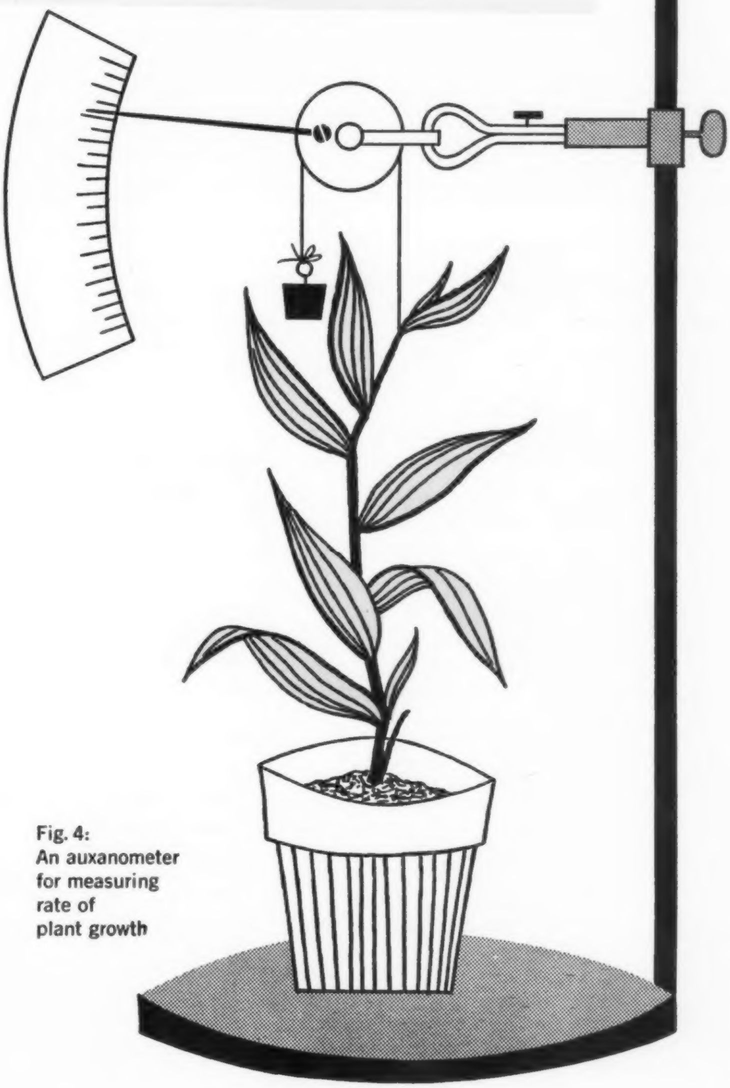


Fig. 4: An auxanometer for measuring rate of plant growth

On the light side

Brain teasers

Down the escalator

It took Jones ten steps and five seconds to walk down a down-moving escalator. Smith, who walked a bit faster, went down the same escalator in twelve steps and four seconds. When the escalator is not running, how many steps are visible?

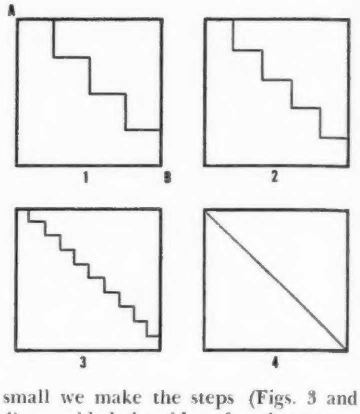
Circular pool

A water reservoir is in the shape of a perfect circle. A fish starts at a point on the edge and swims due north for 300 feet, which takes him to the edge again. He then swims due east, reaching the edge after going 400 feet. What is the reservoir's diameter?

Invisible force

Stand inside the frame of a doorway, your arms straight, and press the backs of your hands against the frame, as shown. Keep pressing firmly for one full minute. Then step out of the doorway. You will experience a strange sensation — as if an invisible force is pulling your arms upward, and they will start to rise slowly.

The experiment illustrates the tendency of overworked muscles to continue to contract for a short time after you have finished using them. Even eye muscles exhibit this tendency. After gazing out of a train window for several hours, for example, your eyes become overworked from following the moving scenery. When the train stops, they will continue to make slight movements. Because the scenery is now fixed, the movements create a momentary illusion that the train is moving backward.

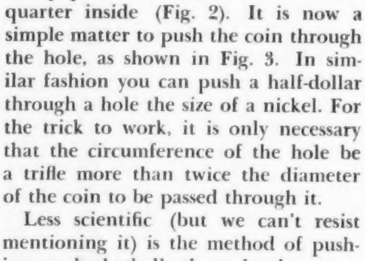


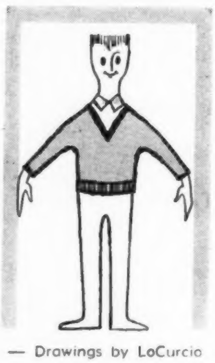
Through the hole

Place a dime on a small square of paper, and trace around it with a pencil. Cut along this line to make a dime-sized hole (Fig. 1). Can a quarter be pushed through this hole without tearing the paper?

The surprising answer is yes. Fold the paper across the hole, with the quarter inside (Fig. 2). It is now a simple matter to push the coin through the hole, as shown in Fig. 3. In similar fashion you can push a half-dollar through a hole the size of a nickel. For the trick to work, it is only necessary that the circumference of the hole be a trifle more than twice the diameter of the coin to be passed through it.

Less scientific (but we can't resist mentioning it) is the method of pushing a basketball through the same dime-sized hole. Just stick your finger through the hole and, with the tip of the finger, give the ball a push!





— Drawings by LoCurcio

Paradox for squares

The four figures at the top of the page illustrate an amusing "proof" that the diagonal of a square is equal in length to twice the square's side!

Suppose the square to be 100 units on the side. In Fig. 1, we drew a zigzag path from corner A to corner B, making each step 25 units broad and 25 units high. The length of this path is clearly 200 units, which is twice the square's side. In Fig. 2, the steps are shortened to 20 units, but the length of the path remains the same. In fact, it remains 200 units no matter how small we make the steps (Figs. 3 and 4), provided the sides of each step are parallel to the sides of the square. Eventually the steps will become so minute that the zigzag path will become a straight line. But it will still be 200 feet long!

Try to explain the fallacy, then check Answers, below.

— GEORGE GROTH

Answers

DOWN THE ESCALATOR: Let n be the number of escalator steps. If Jones took ten steps to reach the bottom in five seconds, then $n-10$ steps must have "gone under" in five seconds. Similarly, for Smith, $n-12$ steps went under in four seconds. Since the escalator moves at a constant rate, we have:

$$\frac{n-10}{5} = \frac{n-12}{4}$$

Solving this equation gives an answer of 20 steps.

CIRCULAR POOL: A right angle with its vertex on the circumference of a circle must intersect the circle at the end points of a diameter. The diameter of the reservoir is therefore the hypotenuse of a right triangle with sides of 300 and 400 feet. The Pythagorean theorem enables us to calculate the diameter as 500 feet.

PARADOX FOR SQUARES: No matter how small we make the steps, they will never vanish. In other words, the zigzag path will never become a straight line.

Young scientists *(cont. from p. 21)*

he carefully removed them from the soil and compared the size, weight, and appearance of the plants, particularly the roots.

A study of hibernation

In the late fall, various species of frogs hibernate. They dig a hole in the mud by ponds and lakes and bury themselves there until spring.

Can hibernation be brought about artificially by reducing the temperature of the surroundings of the frog? One young scientist decided to find out. He placed a frog in a small jar that had two inches of water in it. This jar was placed in a larger jar, with an ice-and-salt mixture packed between the two. By this means he reduced the temperature from 63° to 30° F. The temperature was measured with a thermometer placed in the water of the smaller jar.

The rate of respiration of the frog, as measured by the movements of the floor of the mouth, was used as an indicator of the approach of hibernation. Accurate data was recorded on the respiration rate and the temperature. The studies revealed that as soon as the temperature dropped below 55° F., the frog would close his eyes, expel air from his lungs, and attempt to dig at the bottom of the jar. These were the signs of approaching hibernation. As the temperature dropped below 45° F., the attempts at hibernation increased until finally, at about 34° F., the frog went into complete hibernation.

Growing a complete generation of moths or butterflies

This science-fair entry had its start in the late summer, when the student collected the caterpillars of various moths and butterflies. She carefully wrote descriptions of each, noted the plants on which they were feeding, and then placed each caterpillar in a shoebox, together with some leaves and twigs of the plant. She stored the boxes in a cool place in the cellar of her home. Within a few days, the caterpillars spun cocoons and pupated. In the late winter, the student collected the cocoons she found attached to the twigs in the boxes. She learned that those which, on shaking, did not seem to have a loose, heavy object inside, should be discarded as having been parasitized. The other cocoons were placed in a wire cage. In the early fall the adult butterflies and moths hatched. She succeeded in mating several species and securing fertilized eggs which hatched out. The larvae were then fed on the same kind of leaf as that on which the adult was originally found. — Theodore Benjamin

Stranger than fiction

In World War II, British and American scientists set to work on a top-secret project that produced

The world's biggest ice cube

By Edmund H. Harvey Jr.

■ Early in World War II, British Prime Minister Winston Churchill addressed this solemn message to his chiefs of staff: "I am most anxious that Operation Habakkuk should be pursued theoretically at once, and thereafter, if all is well, on a large scale. I attach the greatest importance to the prompt examination of these ideas. . . ."

Operation Habakkuk was nothing less than a scheme to build warships out of specially treated ice. They would take the form of gigantic, man-made icebergs that would be self-propelled, self-repairing, and practically unsinkable. The planners' main goal was a fully operational ice aircraft carrier, at least two thousand feet long. Eventually, the planners envisioned a whole variety of ice ships, including an unsinkable freighter that could carry as much cargo as a whole convoy of conventional steel freighters.

In the end, such a fleet of ice ships was never built or used in World War II. But just how close the plan came to realization and just how much scientists learned from the attempt make Operation Habakkuk one of the most remarkable stories of World War II.

In the early months of the war, the idea of an unsinkable ship was almost certain to get a serious hearing from President Franklin D. Roosevelt and Prime Minister Churchill, no matter how zany and improbable the idea might sound. Nazi submarines — the notorious U-boats — were inflicting staggering losses on Allied troop and supply convoys crossing the Atlantic. The U.S. war effort hadn't yet hit high gear; transport ships were being sunk almost as fast as they could be built: U.S. anti-submarine forces and their techniques were barely adequate to hold their own against the U-boat menace. Worst of all, there was a lag in the production of crucial materials, especially steel, to build new planes and ships. American and British leaders had to consider the grim possibility that the Atlantic might be virtually blocked to Allied shipping. If that happened, Britain would be left stranded, a sitting duck for Nazi invasion. Allied chances of victory would be drastically lessened, and, at the very least, the war would be prolonged for many months.

Operation Habakkuk was apparently touched off by a rather half-hearted proposal by someone in the British War Office: why not flatten off the top of an iceberg and thus make a floating aircraft carrier in the North Atlantic? The iceberg-carrier could be towed near the main shipping lanes. Anti-sub planes based on it would be within easy striking distance of marauding U-boats.

It was an interesting idea, but not exactly practicable. One of the iceberg-carrier's big disadvantages was glaringly obvious: if it strayed a little too far south for a little too long, it would simply melt away. Furthermore, the proposal didn't take into account the physical properties of ice. Ice is so brittle that one hit by an enemy ship would have left the iceberg in fragments.

The British were just about to write off iceberg airfields as utterly unfeasible when an astounding man named Geoffrey Pyke appeared on the scene. Opinion on Pyke was definitely divided. He was called a genius or a crackpot, a swindler or a great humanitarian, friendly or detestable, depending on who was talking about him. Fortunately, the influential Lord Louis Mountbatten liked and respected Pyke and did much to get a hearing for the eccentric inventor's less fantastic plans and theories.

Pyke had two suggestions for making

⟶

BEFORE THE HIGH BRASS, the general wound up and swung at the cake of ice.

better airfields out of icebergs. First, he said, enclose them in some kind of casing — iron, wood, aluminum, it really didn't matter which. That would hold them together. Second, and more startling, Pyke suggested putting a refrigeration unit inside the iceberg. This would not only keep the berg frozen, but make it self-repairing. If any damage occurred from melting, bombs, or torpedoes, the refrigeration unit would simply freeze enough ocean water to replace the lost ice.

So far, so good, and the British leaders began to take notice of Pyke and his ideas. But the troublesome properties of ice remained. It was just too brittle to be used as a flat, floating landing field, and, even in a casing, the ice would surely crack and splinter with prolonged use.

Pyke wasn't dismayed. He felt there must be some way to make ice stronger, and he knew the man who could probably give him the solution, if anyone could. The man was Dr. Herman Mark, whose work Pyke had come to know during some earlier research. Austrian-born Dr. Mark, an authority on every form of frozen water — ice, snow, glaciers, avalanches — was then, and still is, a professor at Brooklyn Polytechnic Institute.

With an O.K. from the U.S. Office of Strategic Research and Development, Dr. Mark rented space in a New York City refrigeration plant. With an associate, Dr. Walter P. Hohenstein, he set to work "improving" ice. "One of the main things we wanted to find out," says Dr. Mark, "is how ice shaped up as a structural material. So we subjected it to the same tests we would give any potential structural material — say, a new plastic, an alloy of steel, or a new mixture of concrete." With the data from this thorough study of ice's mechanical properties, Dr. Mark and his associate could then set up a basic guide for evaluating the effects of various kinds of ice-reinforcing substances. "We were especially interested," Dr. Mark adds, "in the properties of ice around the freezing point. We knew that would be the ice temperature most prevalent at vulnerable spots on an ice ship.

"We tested a great many reinforcing materials. Glass fiber, silica, and carbon black were eliminated because their strengthening effects didn't outweigh the fact that their specific gravity was higher than water." Being heavier than water, these materials would make an ice ship less buoyant and more liable to suffer crippling damage from the enemy or from natural sources. Finally, Dr. Mark settled on wood pulp — essentially the same kind used to make newsprint — as the best possible reinforcing substance. By making a mixture of roughly 10 per cent wood pulp and 90 per cent ordinary water and then freezing it, Dr. Mark found he could product a tough, strong, plastic-like material capable of being worked like wood. Another encouraging discovery was the fact that a surprisingly small refrigeration unit could keep this pulp-ice frozen indefinitely. The substance was dubbed "Pykrete" in honor of Geoffrey Pyke.

Pykrete's relation to ice is somewhat like steel's relation to cast iron. Pykrete is almost as hard as pure ice, but its blending strength and resiliency are better. Pyke calculated that a one-inch column of Pykrete could support the weight of six men. The substance would also resist melting far better than ordinary ice: a five-foot cube, for example, had to be boiled for four days before it finally disappeared!

Another one of Pyke's calculations indicated that Germany's biggest bomb would make little more than a dent in a thirty-foot-thick slab of Pykrete. The bomb's crater, he estimated, would be a mere three feet deep and twenty feet in diameter; it could be "repaired" almost instantly by a spray of supercooled water. A carrier with a Pykrete hull thirty feet thick, Pyke concluded, couldn't be hurt by bombs, torpedoes, or even long cruises in warm ocean currents. Melting would be instantly counteracted through a system of refrigerant-carrying tubes to every part of the ship.

There's no vouching for the truth of some of the stories that have grown out of Operation Habakkuk. But two are worth repeating here for the fun of it. Lord Mountbatten, so one story goes, first saw and tested a Pykrete sample in London. He was so enthusiastic that he marched directly over to Churchill's residence, block of Pykrete in hand. When he arrived, he ignored the butler's insistence that Sir Winston was taking a bath and did not wish to be disturbed. "All the better," said Lord Mountbatten. He strode up the stairs, burst in on Churchill, and dropped the chunk of Pykrete in the Prime Minister's steaming bath. Churchill was so impressed by this "un-

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See also: p. 32

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meltable ice" that he ordered Mountbatten to take some Pykrete to the Quebec Conference of 1943 and demonstrate its remarkable properties to the assembled American and British military and government leaders. This Mountbatten did at Quebec. As Churchill tells this story, Mountbatten had one of his staff wheel in two large blocks of ice — one was common ice, the other Pykrete. He then invited the strongest man present to attack the blocks of ice with an ice chopper. The job fell to General "Hap" Arnold, who flexed his muscles, got in position, and swung the chopper. The ordinary ice split under one blow. Arnold next swung at the Pykrete, but dropped the chopper with a cry of pain. The Pykrete suffered little damage, but Arnold's arms and shoulders had been badly jarred. Next Mountbatten whipped out his pistol and fired, first at a chunk of ordinary ice (which shattered, of course) and then at a block of Pykrete. The bullet ricocheted from the Pykrete and, according to one version, tore off one of Lord Mountbatten's epaulets.

Whether these anecdotes are true or not, it *is* true that, by the spring of 1943, Allied leaders were convinced that the idea of an ice aircraft carrier was not so fantastic after all. They gave the go-ahead for construction of a pilot model.

Lord Mountbatten dramatically demonstrated the 'unmeltable ice,' one story goes, by dropping a chunk into the Prime Minister's steaming bath.

The Pykrete model ship was built on Patricia Lake near Jasper, Alberta. Christened *Habakkuk I*, the ship was sixty feet long, thirty feet wide, and twenty feet deep. It was equipped with engines that pushed it along at almost ten miles per hour, a refrigeration unit, and a great deal of other trial machinery. This ice ship performed as well or better than the Habakkuk scientists had anticipated. Even though the water temperature reached 60° F. for several weeks, the ship did not melt, crack, or lose its shape in any way.

The stage was now set for the actual construction of a full-scale aircraft carrier. Its name had already been chosen: *Habakkuk II*. Pre-construction statistics called for a ship two thousand feet long, three hundred feet wide, and one hundred feet deep. Displacement: 1,700,000 tons. Crew: some 1,700 officers and men, in quarters comfortably insulated against the cold. Power to turn the giant screws would be supplied by thirteen electric motors — six on each side and one at the stern. The holds would house, in bomb-proof hangars, up to two hundred single-engined Spitfire fighters *plus* one hundred twin-engined Mosquito light bombers. A series of giant elevators would lift the planes to the flight deck in minutes. Estimated cost: $70,000,000. And, at that price, a real bargain, for the ship offered a way of reducing demand on structural materials such as steel.

After much deliberation, a coastal town in Newfoundland, called Corner Brook, had been picked as the building and launching site for *Habakkuk II*. Of all the towns on Canada's Atlantic coast, Corner Brook seemed to offer the best combination of water temperature, weather, convenient wood pulp factories, deep water, and seclusion — all vitally needed for the successful building and launching of the massive ice ship.

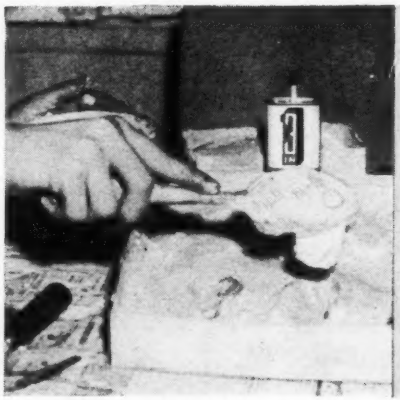
Then, abruptly, Operation Habakkuk passed into history. Orders were received at Corner Brook to halt all work and cancel plans for keel-laying. What had happened was simply this: steel production was rapidly increasing, and the U-boats were no longer much of a menace. New anti-sub devices on planes and ships were proving highly effective, and U-boats were losing their sting. Quite understandably, the Allied chiefs of staff decided that Habakkuk's $70,000,000 allotment would be better spent on air power.

Though Operation Habakkuk never achieved its goal, it was in many ways a success. The theoretical knowledge gained about ice has been proving invaluable ever since to scientists and engineers, both military and civilian. The U.S. Army's Snow, Ice, and Permafrost Research Establishment in Wilmette, Illinois, is now dealing with much the same kind of problems as those involved in Operation Habakkuk, and it is something of a tribute to Dr. Mark that his 1942 report on the mechanical properties of ice is still classified "Restricted" by the Army. It is no secret, however, that the military is doing a great deal of research on the problems of living and fighting in arctic regions. And it wouldn't be rash to suspect that a substance much like Pykrete is figuring strongly in plans for building arctic roads, bridges, tunnels, and runways.

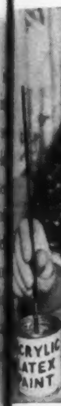
What about ice ships? Maybe the best possibility for them right now is as replacements for Atlantic weather ships. In this role, they could double as weather stations and emergency landing spots for both planes and ships. But the ghost of Operation Habakkuk could turn up almost anywhere and, when it does, there's no doubt that it will be a strong, tough, icy ghost.

1. In a low-sided cardboard box, large enough to hold specimens, mix plaster of Paris with water to a smooth paste. Smooth surface of wet plaster with spoon or spatula. Grease or oil specimens thoroughly with vaseline or household oil to prevent them from sticking to the plaster when embedded.

— Photos from Rohm & Haas Co.



4. Fill specimen cavities top and bottom molds w wet plaster and quickly top mold over bottom m When plaster models have pry molds apart carefully with equal care, pry mod out. Small bubbles in surfa of models can be filled w wet plaster, which you apply with small paint bru



Life-scale models:

■ For a fascinating summer project, try making life-size models. All you need in the way of materials is: plaster of Paris, water, small cardboard boxes, vaseline or household oil, a spoon or spatula, a mixing bowl, specimens of what you want to model, and a few other household items.

One general technique can be used to make many kinds of models. This is the same technique employed by workers in museums of natural history. It can produce such scientific artistry as that found in "Neptune's Kingdom" at Pacific Ocean Park, Santa Monica, California. Here, an entire tropical ocean bottom has been reproduced and enlarged for all to see. The specimens are four times as large as their living counterparts and show details of structure that would ordinarily go unnoticed.

In learning to model, however, it's best to start by making exact replicas in natural size. In this case, actual specimens can be used to make molds in which the models are formed. Begin with simple plants or animals. Snakes, worms, starfish, sea shells, and some fish are good subjects. Avoid frogs, insects, and other more complicated creatures.

After selecting one or two specimens to model, follow the steps outlined in the pictures and captions.

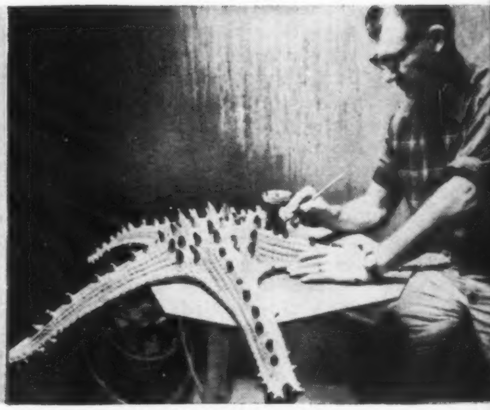
Finished models can be displayed on a wooden board. To make the scene realistic, you may want to include large artificial rocks. These are made by shaping a ½-inch mesh wire screen to the desired form, tacking it to the wooden base, and covering it with burlap or rags — loosely enough to follow all the contours of your final "rock." A layer or two of rather "sloppy" plaster is poured and brushed on the cloth and allowed to set firmly. Then the rock is painted with acrylic latex paint to the desired natural color. An appropriate background scene can be painted on a piece of poster board (or heavy cardboard) attached to the back of the wooden base. Place your models among the rocks, and your

[Em]bed greased specimens [ha]lfway into plaster mix (but [no] deeper, or they may be [ha]rd to remove later). Rock [ea]ch specimen gently with a [fin]ger to eliminate trapped air [bu]bbles. After plaster has set, [re]move specimens, grease [th]em again on all sides, and [pu]t them back into the mold.

3. After greasing mold's flat surface, cover it and embedded specimens with wet plaster to form a top mold. When set, pry two molds apart and remove specimens. Grease specimen cavities. If any cavity is more than an inch in any dimension, insert fine wire to reinforce model.

5. Paint models with acrylic latex paint, a water-thinned paint that can be applied directly on damp, fresh plaster. Paint sprayer can be used (if available) for general areas, a brush for fine detail work. Paint dries in about half an hour, so a slip of the brush can be painted over after a short wait if necessary.

Right: Professional scenic artist paints tiny pincers on giant model of starfish.



— Photo from Sinclair Paint Co.

museum caliber

museum exhibit is ready to be shown.

Enlarged-scale models of specimens are considerably more complicated to make. If you make them carefully, however, the results are well worth it. Even microscopic subjects can be modeled. First step is to take and enlarge a few sharp, clear photos of the specimen. Or, for some types of specimens, simple shadowgraphs will do. Shadowgraphs are made by placing the specimen in a photographer's enlarger, then exposing a sheet of light-sensitive photographic paper to the shadow.

When your photos or shadowgraphs are ready, you can determine the size of the model you desire. You may prefer to use the exact size of the photo, or you may want something even larger. In scaling up a specimen, use the equation below to determine the correct size of each part.

Make a sketch of the proposed model in the desired size and mark all measurements. From balsa wood (use white pine or sugar pine for some types of specimens), cut out and roughly shape the major parts of the specimen. Rough up the surface of the wood with coarse sandpaper or a wire brush. Coat it with a layer of plaster, and work in as many surface details as you can while the plaster is setting. For very large specimens, plaster small areas at a time.

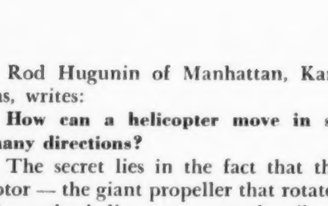
After the plaster has set, the fine surface details can still be worked with a knife, assorted drills, etc. Then the model is painted, as described in step 5 above. Stiff wires may be inserted in drilled holes to simulate hairs. The model is then ready for mounting.

$$\frac{\text{actual size of specimen (or size in photo or shadowgraph)}}{\text{desired model size}} :: \frac{\text{size of specimen part (or its size in photo or shadowgraph)}}{\text{size of model part}}$$

Rod Hugunin of Manhattan, Kansas, writes:

How can a helicopter move in so many directions?

The secret lies in the fact that the rotor — the giant propeller that rotates above the helicopter — can be tilted. When the rotor is horizontal, the craft can move only in a vertical direction. The speed at which the rotor is turning and the pitch (or angle) of its blades determine whether the craft moves straight up, straight down, or simply hovers. For forward, backward, or sideward movement, the entire rotor is tilted in the desired direction. If, for example, the rotor is tilted toward the craft's tail, the helicopter moves backward. It does so because the rotor's blades are now taking a bigger bite from the air in back than from the air in front.



Joseph Fortune of Burlington, Vermont, writes:

What is spontaneous combustion?

Spontaneous combustion is a fire that seems to start itself. It occurs when a substance oxidizes (combines with oxygen) in a confined place such as an attic or closet. Oxidation liberates heat. If the heat cannot easily escape, it accumulates in the substance; the temperature increases until the substance reaches its kindling point. At that instant, the material catches fire. Consider a pile of cotton rags soaked with linseed oil. Linseed oil oxidizes slowly. Ordinarily, the heat from this oxidation is carried away by the air. But suppose the oil-soaked rags are piled in a closet. Cotton rags are poor heat conductors, and there is little circulating air to carry the heat away. Finally, the linseed oil reaches its kindling temperature (which may be as low as 120° F., depending on various conditions) and bursts into flame.

Michael Mulhern of Ridgewood, New Jersey, writes:

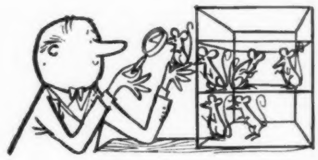
How many light-years distant is the sun?

The sun's average distance from the earth is about 1/60,000 of a light-year. Obviously, this distance is easier to express as 93 million miles. But stars other than the sun are at much greater distances from the earth. Astronomers thus find it more convenient to express these distances in light-years. A light-year is the distance light travels in a year — about 6 trillion miles. The nearest stars are about 4.3 light years (25.8 trillion miles) away.

Frank J. Ross Jr. of Livonia, Michigan, writes:

Do cobras really respond to the music played by an Indian snake charmer?

No. Cobras — like all snakes — are unable to hear. They have **no ear** openings or eardrums. Most zoölogists agree that cobras are "charmed" by the constant movement of the snake charmer's pipe and the swaying motion of his body as he plays. Movement excites the cobra, causing it to raise the front part of its body. If aroused further, the snake will strike. The charmer's skill lies in maneuvering the cobra so that it will remain excited but won't strike or try to escape. Even if the snake does strike, its action is so slow that a snake charmer can usually avoid any harm.

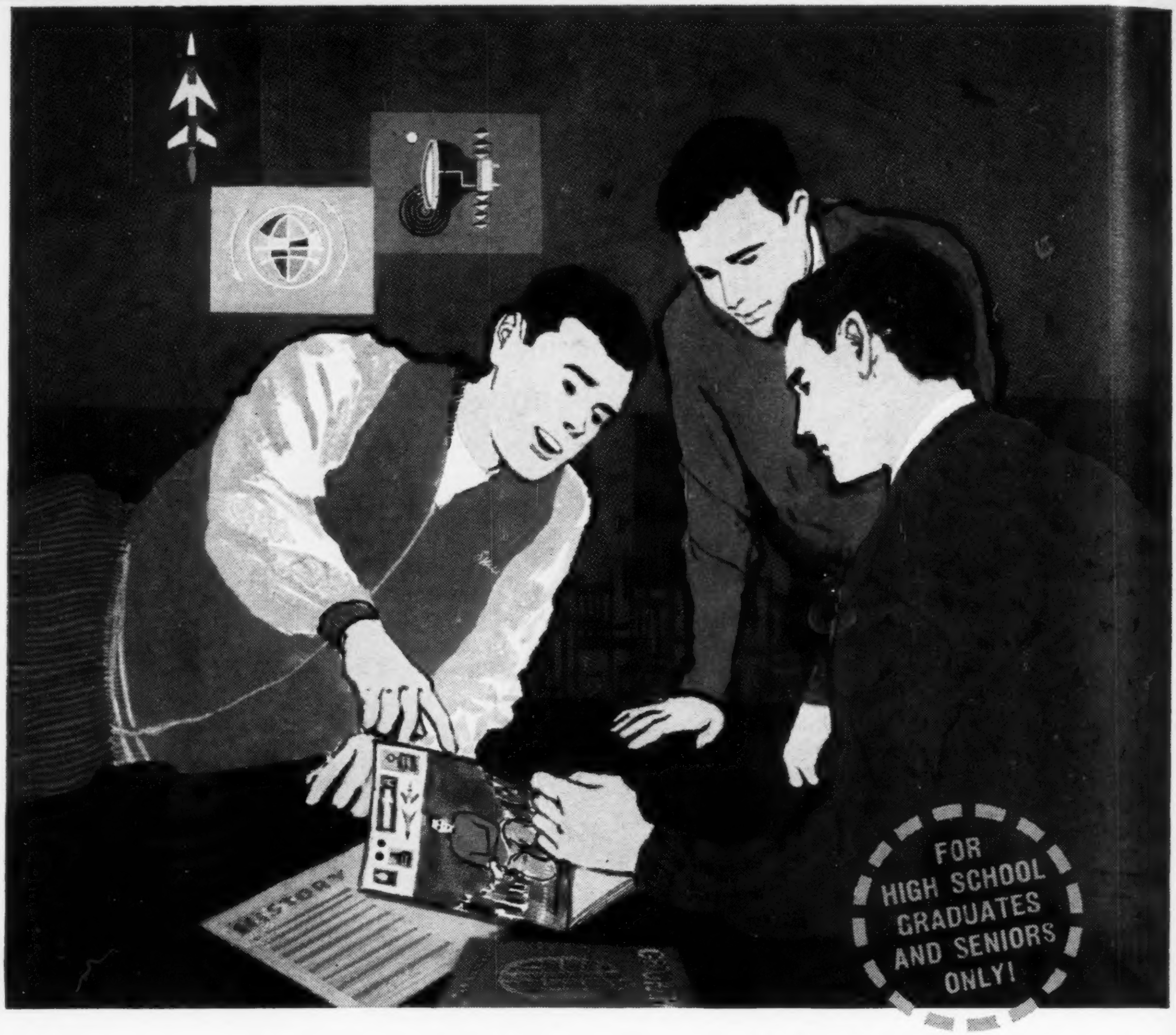


William L. Smith of Buffalo, New York, writes:

Why do scientists use mice in experiments on human disease?

Since humans obviously can't be used in most experiments, scientists must turn to animals. Mice are ideal experimental animals for many reasons. Here are some of them: First, there's no shortage of mice — they can be found almost anywhere. Second, because of their small size, they can be easily housed and cared for. Third, they are fast-breeding — a pair of common house mice, for example, may multiply to 1,000 mice within a year's time. Fourth, and most important, they are susceptible to many of the diseases that attack humans.

Questions from readers will be answered here, as space permits. Send to: Question Box, Science World, 575 Madison Avenue, New York 22, N.Y.



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INSTRUMENT & APPARATUS COMPANY's Travel-Lab makes it possible to "scientize" elementary and junior high classrooms in a hurry. The Travel-Lab and a Travel-Lab Apparatus Kit were designed by G. H. Olewin, Department of Physics, University of Texas, as a much-needed aid to the teaching of science concepts at all grade levels. The Travel-Lab includes an efficient mobile demonstration bench with acid-resisting plastic top, support rods, microscope and balance compartments, a 15-foot extension cord and reel, and magnetic latches on doors and drop leaves. Working area is 48 x 17 inches, and the height, 36 inches. (*For further details, check No.* 519*A*.)

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Science teacher's question box

How much of the rain that falls on land actually reaches the oceans? — G. B., New York, N. Y.

Some 20 to 40 per cent. The rest evaporates into the air from land surfaces and inland waters.

How can wood-destroying molds be grown in the laboratory? — S. S. T., Dallas, Texas.

Fill about a third of a screw-top jar with moist soil. Put in a small piece of wood, screw the top on tightly to retain the moisture, and leave the jar in a warm, dark place. Mold will form on the wood.

What do barnacles feed on? — M. N. S., Trenton, N. J.

According to G. K. Howard and Henry C. Scott of the Hopkins Marine Station in California, the barnacle *Mitella*, which is fixed on rocks, is oriented to receive the downwash of waves. With its extended cirri, it grasps worms, crustacea, clams, and algae. The barnacle *Lepas*, which is attached to floating timber, actually behaves like a predatory carnivore, capturing and devouring amphipods, gastropods, and worms. When the timber and its passenger become stranded on the beach, *Lepas* is known to ingest even fragments of shells and chunks of granite.

How can my students grow *Daphnia* (water fleas) to feed our tropical fish? — B. S., Brooklyn, N. Y.

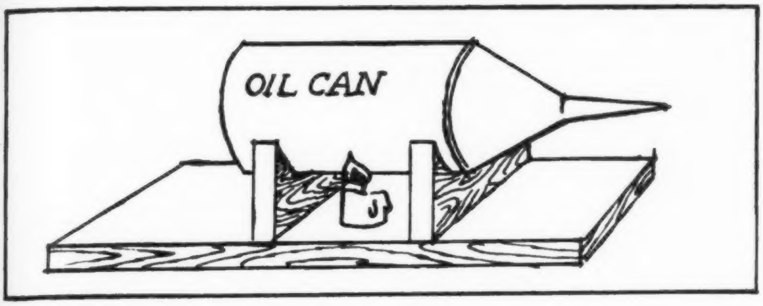
Allow tap water to stand in a clean glass jar for several days to permit the escape of harmful gases such as chlorine. Place the jar of water in very bright sunlight, and add green algae. These must be the round type usually found on the walls of aquariums. Allow this "green algae water" to stand for three days, then add 3 cc. of very finely mashed hard egg yolk. Also add a bit of dried yeast previously made into a suspension in water. Finally, add living *Daphnia* purchased from a pet shop. Keep the tank at a temperature of between 12° and 24° C. (53° to 75° F., approx.). You will get a luxuriant growth of *Daphnia*.

In the November 5, 1957, issue of *Science World*, Dr. Asimov states in the article, "102 Names," that the discoverers of number 102 . . . "named it nobelium." In the issue of *Scientific American* of July, 1958, element 102 is again referred to as "nobelium," yet on a very recent program of "Continental Classroom," Dr. Harvey White made a statement to the effect that element 102 has not yet been named.

I would appreciate clarification of these statements. — Mrs. R. W. K. Jr., Marshall, Mo.

Element 102 as yet has no official name. However, many scientists are referring to it as "nobelium," the name that has thus far received the most popular support. Therefore some people use the name nobelium, while others do not yet accept its use.

How to do it



Demonstrating jet propulsion

Here is a simple way to demonstrate jet propulsion or to illustrate the conversion of chemical energy to heat energy to mechanical energy.

Mount a can with a small spout (such as an oil can) over a candle on a floating board, as shown above. Put water in the can, and light the candle. The steam issuing from the can's spout will move the board in the opposite direction.

Demonstrating the effect of the slanting rays of the sun

One of the difficult concepts to present to science students is the decrease in solar radiation received as one travels away from the equator and the causes for the seasonal changes in temperature. The most commonly used device consists of a cardboard sheet containing ruled lines, together with dowel sticks representing rays of the sun. With this device, the number of rays falling in a given area of the earth with the axis in different seasonal positions is counted. Actually, this is only a type of analogy.

It is possible to demonstrate this phenomenon quantitively. The necessary materials are a large geography globe, a photoelectric exposure meter usually used for photographic purposes (or a photronic cell and galvanometer), and a flashlight. The flashlight is pointed at the globe as indicated in the diagram (*below, left*). The exposure meter (or the photronic cell with connections to the galvanometer) is placed at various latitude positions on the globe. The exposure meter (or galvanometer) reading can then be noted for the various latitudes. This is repeated with the axis in the different seasonal positions.

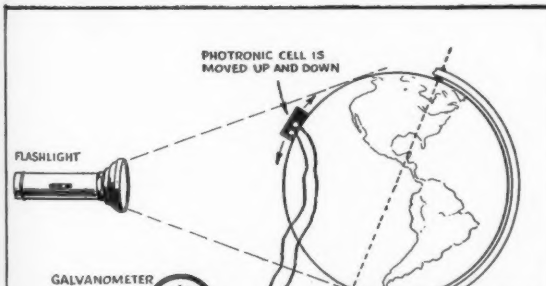
If a photronic cell and large galvanometer are used, the visibility for the class is increased. To prevent damage to the exposure meter or to the photronic cell, the flashlight must not be too brilliant. It is also wise to darken the room to remove the effect of external light.

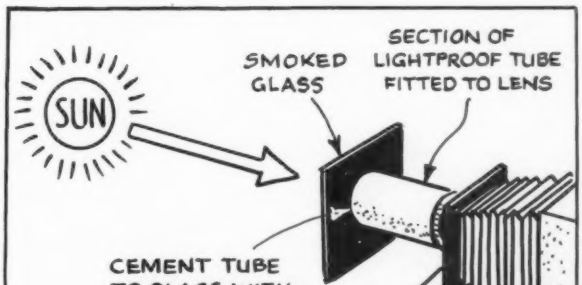
Photographing the sun

Before starting this activity, warn students not to look at the sun directly with the naked eye or through any optical device not designed for solar observation.

To photograph the sun, a high-density filter is required to keep the film from becoming fogged. If a focusing camera is used, set its focus scale at infinity. Fit a cardboard tube over the camera lens, as shown (*below, right*). Cement a piece of glass to the front of the tube. Smoke the front of the glass with the flame of a candle. This serves as the filter.

The camera is now ready to take pictures of the sun's disk. Several exposures of varying periods of time should be made. When the film is developed, the best exposure will be apparent. Very dense, fogged negatives may be used in place of the smoked glass.





— Drawings courtesy of Popular Science

Science World Index

Vol. 5, 1-8 • Feb. 10, 1959 — May 19, 1959

Following abbreviations are used: F-February; Mr-March; A-April; My-May. Major articles are indicated by an asterisk. Articles from SW departments are keyed as follows: (C), Careers; (N), Science in the news; (SF), Science fiction; (SWI) Science World interview; (STF), Stranger than fiction. Date of issue is followed by page number — F18:2 (February 18 issue, page 2). Index does not include News department for May 19.